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REINFORCED CONCRETE AND TILE CONSTRUCTION, MARLBOROUGH HOTEL ANNEX, ATLANTIC CITY, N. J.

An interesting combination of reinforced concrete and burnt clay tile has been adopted for the construction of the new annex to the Marlborough Hotel, now nearing completion at Atlantic City, N. J. Described in a few words, the structural framework of this building, including columns, girders and roofs, is reinforced concrete, while the walls and floor filling are burnt clay hollow tile. The combination is not wholly new, it having been employed in a number of structures; but it has never before been used in a building of such size and importance, or in one in which the variety of structural forms to be detailed was so great. This Atlantic City work represents, therefore, in an exceptionally perfect manner, the possibilities of the combination construction, of which it is at present the most notable example.

The Marlborough Hotel is one of the largest and most famous of Atlantic City hostelries. Its new annex is practically a separate and an even larger structure, located parallel to the older building and connected with it only by covered passageways. The architectural appearance of the new building and its location with respect to the older building are shown clearly by our front-page picture. As will be seen, it consists of a lofty ocean wing, or front, of ornate design, and of a parallel rear wing of less height, connected to the front portion by a structure 147 ft. long and 47 ft. wide, designated as a center wing. To the ocean wing there is joined a two-story crescent-shaped structure—a "solarium"—the ends of whose horns reach to the famous boardwalk along the beach and embrace an open plaza. The main dimensions of the structure as described are: Length from front to rear, excluding solarium, 326 ft.; width at wings, 128 ft.; height to top of main dome, 164 ft., and height to roof line 96 ft.

The type of construction adopted, namely, combination reinforced concrete and tile construction, was determined largely by business considerations. As the new building was to be constructed in close proximity to a hotel whose guests were largely wealthy people, little disposed to endure inconvenience or noise, it was determined from the first to do away with structural steelwork so far as was possible. The noise of riveting, it was feared, would deplete the hotel of its guests. In choosing a substitute, however, several desiderata had to be kept in mind. A fire-resisting construction equal at least to steel and tile had to be chosen. This construction had, moreover, to be one which would not materially exceed in cost ordinary steel and tile construction, and which would not take any greater time to complete. These qualifications were found by the architects to be most nearly obtained by using reinforced concrete for the structural framework and burnt clay hollow tile for walls, partitions and floor filling. This construction was adopted, and has been carried out according to the designs now to be described.

GENERAL STRUCTURAL DESIGN.—The general structural design of the building can be most readily understood in connection with the typical floor plan Fig. 1 and the front-page picture. It consists of a suitable arrangement of columns resting on pile-supported reinforced concrete slab footings and extending generally to the roof line. At each floor these columns carry a system of wall and floor girders, and at their tops they support the roof framework. The roof girders and slabs are reinforced concrete. The slabs between floor girders are in some places reinforced concrete, but generally are a special construction composed of closely spaced parallel beams of reinforced concrete filled between with hollow tile; the exterior walls are hollow tile, with pebble-dashed plaster finish and terra cotta ornamental details.

COLUMNS AND FOOTINGS.—The column arrangement differs somewhat in different stories, but in general is substantially as shown by the plan Fig. 1. In the rear and main wings the arrangement is rectangular, and, with one or two exceptions, uniform from foundations to roof. In the front wing the column arrangement is as shown by Fig. 1 to the sixth floor level; at the sixth floor the roof of the main wing intersects the front wing, causing a change in the column arrangement, and further changes develop as the main and side towers are gradually separated from the body of the building. The general character of these changes is a discontinuation of lower story columns as the necessity for them ceases and the introduction of new lines of columns to form the polygonal framework of the towers. Where new lines of columns are introduced they take footing on special girders carried by pairs of columns in the story below, as shown by Figs. 4 and 5.

All columns taking footing on the ground are carried by timber piles capped with reinforced

MARLBOROUGH-BLENHEIM HOTEL, ATLANTIC CITY, N. J.

in cement mortar and carried on the wall girders at floor levels. The character of the block tile wall construction is clearly shown by the drawings of Figs. 6 & 7. The outside of the wall tiles are given a finish consisting of a pebble-dashed coat of 1 : 1 cement mortar.

ROOFS.—The roof work comprises pitch roofs for the center and rear wings, the wings of the solarium and the large dormers, arch roofs for the small dormers, and dome roofs for the main and small towers, and for the ballroom in the solarium. These roofs are all constructed of reinforced concrete.

The roofs of the center and rear wings are double pitch roofs with ridge lines on the axes of the wings. They are supported at the eaves by the wall girders at that level and at the tops of the main slopes by longitudinal 10 x 24-in. girders connecting the interior columns. The roof slab is continuous over the ridge and between opposite eave lines, and is divided by the interior column girders into three bays, one center bay and two side bays. The slab in the center bay is unstiffened, but those in the side bays are stiffened every 12 ft. by 10 x 20-in. and 10 x 18-in. rafters reaching from the interior column girders to the wall girders at the eaves. All girders and rafters are made flush with the top of the slab, and are of stone concrete. The slab itself is 6 ins. thick, of 1 : 2½ : 5 cinder concrete, with reinforcing bars parallel with the rafters and 16 ins. apart.

In each slope of the center wing roof there are four small dormers, and one large dormer, occupying spaces between rafters. The ridges of the large dormers intersect the main roof at the levels of the interior longitudinal girders, and they have double pitch roofs and vertical sides. The small dormers have semicircular arch roofs and vertical sides. In both large and small dormers the roof and sides are a continuous slab without ribs, and reinforced by continuous bent rods set parallel to each other and transversely to the axis of the ridge.

The pitch roofs for the wings of the solarium are shown in plan and section by the drawings of Fig. 8. As in all other roofs, the slab is of cinder concrete and the girders of stone concrete. In all other respects the drawings give the details clearly; they also show the construction of the vaulted arch roofs of the pavilions terminating the wings.

The dome roofs for the central and side towers of the main building and that for the ball room in the solarium are shown by the drawings of Figs. 8 and 9. Referring to the main tower dome construction first, it is to be noted that the tower is 64 ft. in diameter up to the ninth floor line, where it is reduced in diameter to 54 ft. The reduction is accomplished by shifting the exterior circle of columns 5 ft. inward, as shown by the ninth floor plan, Fig. 5. These new exterior columns are carried to the springing line of the dome, while the interior columns continue about two stories higher to an intersection of the curved ribs of the dome. The arrangement is clearly indicated by Fig. 9. There are eight ribs in the dome roof, one reaching from each exterior column to the continuous octagonal girder supporting the lantern and taking support about midlength on an interior column. The tops of these interior columns are connected by horizontal girders, forming an octagonal ring supporting the dome shell, which covers the ribs. In designing the dome, the lower portion of the shell and ribs was considered as a sort of flying buttress supporting the tops of the interior columns against the thrust of the central portion of the dome and its superior cumbent load.

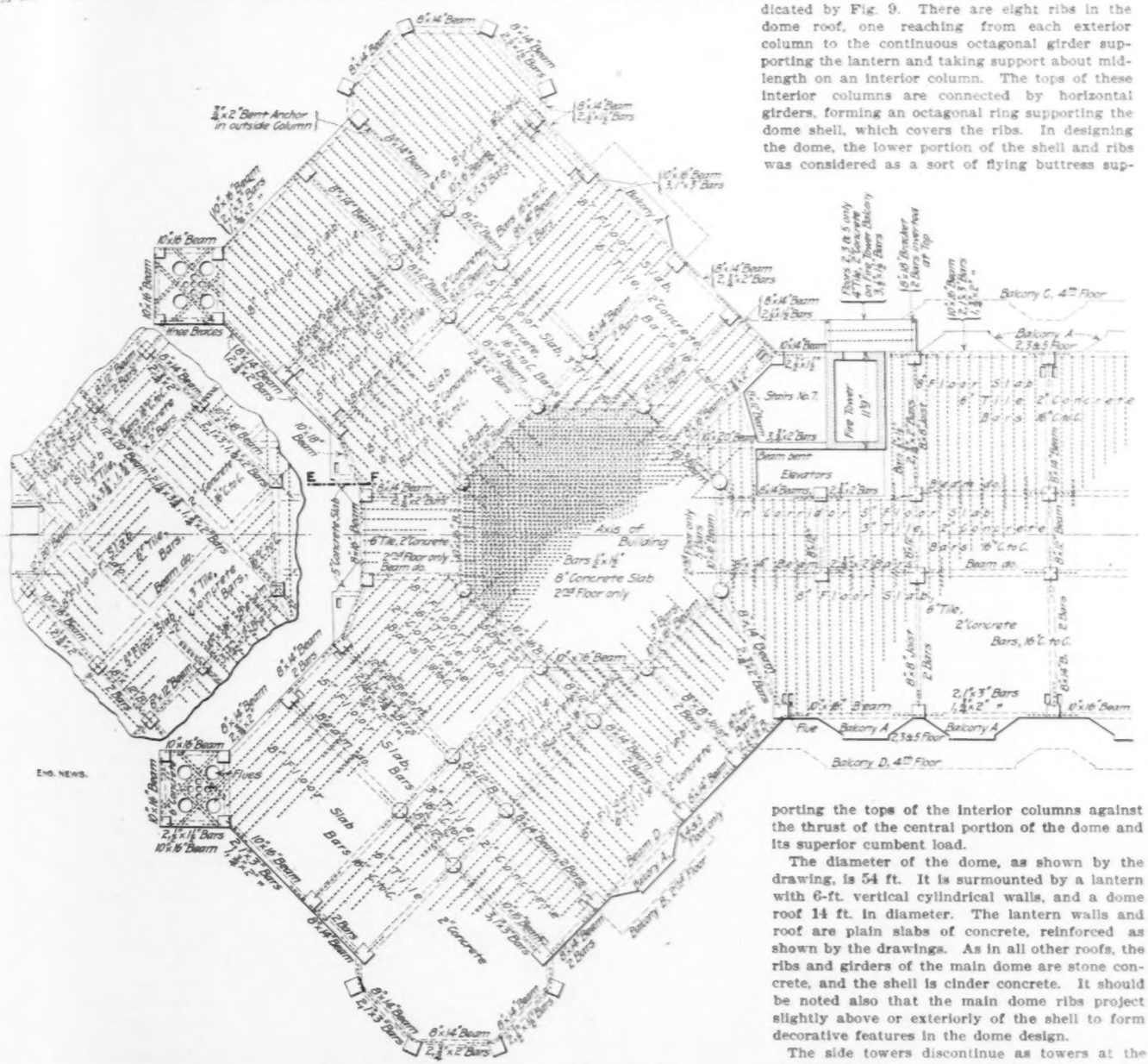


FIG. 3. GIRDER AND COLUMN LAYOUT IN FIRST TO FIFTH TOWER FLOORS.

The diameter of the dome, as shown by the drawing, is 54 ft. It is surmounted by a lantern with 6-ft. vertical cylindrical walls, and a dome roof 14 ft. in diameter. The lantern walls and roof are plain slabs of concrete, reinforced as shown by the drawings. As in all other roofs, the ribs and girders of the main dome are stone concrete, and the shell is cinder concrete. It should be noted also that the main dome ribs project slightly above or exteriorly of the shell to form decorative features in the dome design.

The side towers discontinue as towers at the eighth floor; above this point they continue as a cupola of smaller diameter. The reduction in diameter is accomplished in much the same way as it is in the main tower, and as clearly indicated by the eighth floor plan, Fig. 4. The eight columns, shown in section in Fig. 4, extend to about the height of the tenth story, where they are connected by a 13½ x 14-in. circular girder of reinforced concrete, with an inside diameter of 15 ft. 9 ins. On this girder is sealed the hemispherical dome roof, with an interior diameter of 16 ft. This dome is a plain slab, there being no stiffening ribs of any sort, and is reinforced by radial and circumferential bars.

The dome roof of the ballroom is notable chiefly for its flatness. With a diameter of 42 ft., it has a rise of only about 5 ft., as shown by the drawings of Fig. 8. These drawings explain the method

concrete stepped piers. There are 159 of these piers. They vary in size. For the center and rear wing columns and for the majority of those in the front wing the piers are 7 ft. square at the base and rest on a cluster of from five to ten piles, depending on the load. These piles were driven by water jet into the clean, coarse beach sand. They were sunk about 20 ft. and cut off below water level to receive the concrete piers. The pier construction was comparatively simple; the base course was generally a 2-ft. 3-in. slab carried 12 ins. below the pile tops and reinforced about 2 ins. above this level by a layer of Kahn trussed bars. The top course was uniformly 12 ins. thick, and was molded with a mortise reaching the full depth and 12 ins. square to receive a tenon on the foot of the column. The footing concrete was a 1 : 2½ : 5 mixture of ¾-in. broken stone.

The footing construction includes, besides the column piers, a beam support for the first story walls of granite ashlar masonry. These beams connect the wall column piers all around the building at a level about 4 ft. below the surface, and are simple reinforced concrete girders. A typical girder between center wing wall columns is 22 ins. wide and 12 ins. deep; the reinforcement consists of three ¾ × 2-in. × 18-ft. Kahn trussed bars at the bottom and two 9-ft. bars of the same size at the top.

The column construction proper is shown by the drawings of Fig. 2. The octagonal section is used only for the main tower columns in the first story, or lobby floor, and the circular section only for the same columns in the second story, or exchange floor. All other columns are rectangular in section. The column reinforcement is indicated clearly by the drawings. It is interesting to note that the hooped sections were designed for a unit stress of 850 lbs. per sq. in., while those without hoops were designed for a unit stress of 500 lbs. per sq. in.

FLOORS.—The floor construction is a system of girders carried by the columns and supporting slabs of reinforced concrete or of combination reinforced concrete and tile construction. In the center and rear wings the bays formed by the girders are generally rectangular in form; in the front wing the floor bay arrangement is irregular and changes from story to story above the sixth. To explain briefly, the front wing, as shown by the front-page picture, is several stories higher than the center and rear wings. Up to the sixth floor the floor framing plan is the same for all floors, and is as shown by Fig. 3. At the sixth floor the outside walls of the front wing begin to be continued around the side next to the center wing, so that by the time the seventh floor is reached the front wing is entirely separated from the other wings. At this level also the main and small octagonal towers begin to be developed, and at the eighth floor their separation from each other and from the other portions of the front wing is complete. At the eighth story the floor frame work of the small towers is as shown by Fig. 4, and at the ninth story the floor framework of the main tower is as shown by Fig. 5.

The construction of the girders calls for brief mention only. They are dimensioned and reinforced according to the loads coming on them.

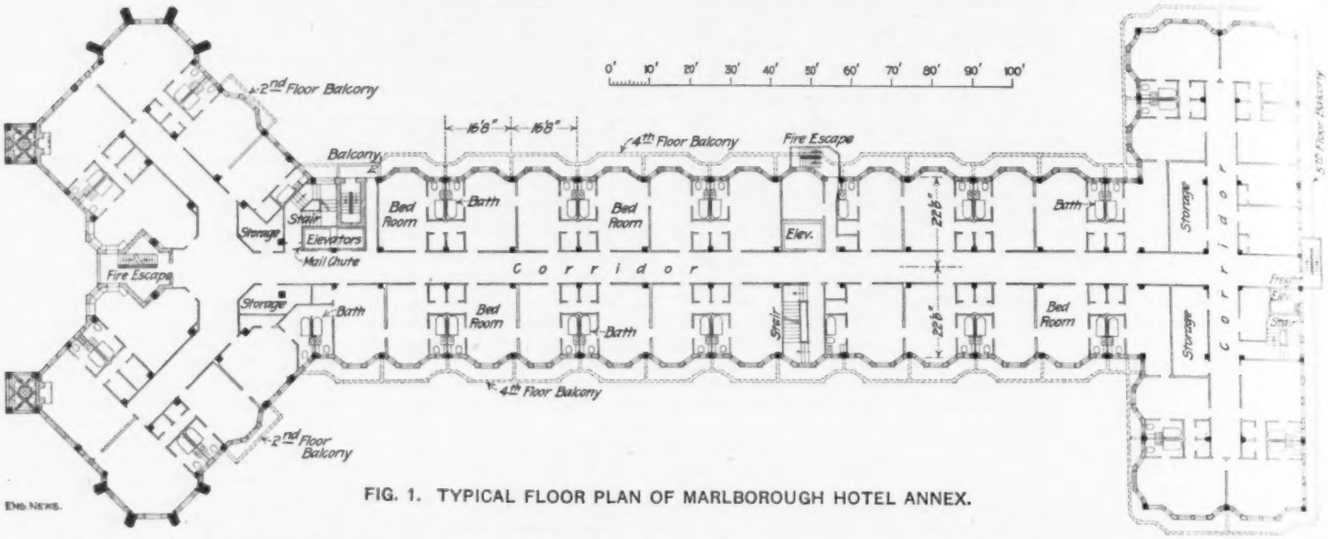


FIG. 1. TYPICAL FLOOR PLAN OF MARLBOROUGH HOTEL ANNEX.

The filling slabs between girders are straight reinforced concrete in certain bays of the lower floors in the front wing, but in all other places they are a combination construction of reinforced concrete and clay tile. The character of this combination is indicated by Fig. 6; in explanation it may be noted that the width of the tile fillers, the distance between rows of tiles and the depth of the concrete cover are intended to remain constant at 12 ins., 4 ins. and 2 ins., respectively, but the depth of the tile will be altered to vary the depth of slab according to the span and load. In the building being described 8-in. slabs are used for the longer spans and 5-in. slabs for the shorter spans, the depth of the tiles being, respectively, 6 ins. and 3 ins.

By a glance at the drawing Fig. 6 it will be seen that we have in this construction a 2-in. concrete slab stiffened every 16 ins. by reinforced ribs filled between with hollow tiles of suitable dimensions to give a flat ceiling. In designing such a slab the concrete is figured to take all stresses, the tiles being considered simply as fillers. As a matter of fact, however, the tile will have a certain amount of arch action and thus add to the strength of the floor. In designing the floors a live load of 75 lbs. per sq. ft. was assumed for the lobby and exchange floors, and of 50 lbs. per sq. ft. for all other floors. The strength of concrete was taken at 2,400 lbs. per sq. in., and it was proportioned for unit stresses of 500 lbs. per sq. in. for live and dead [illegible] and of 750 lbs. per sq. in. for wind stresses. [illegible] responding unit stresses for reinforcing [illegible] were 16,000 lbs. and 22,000 lbs. per sq. in.

The straight reinforced concrete slab [illegible] tion is confined to two octagonal bays [illegible] the lower portion of the lobby and the [illegible]nge floors. As will be seen by Fig. 3, eight columns, set equidistant on the periphery of a 32-ft. circle, are connected by girders forming an octagonal bay. This bay is covered by an 8-in. slab reinforced by two layers of bars intersecting at right angles and spaced from 6 ins. apart at the center to 12 ins. apart at the sides. The slab is also bonded with the slabs of adjacent bays by bars spaced 32 ins. apart and crossing the circumferential girders at right angles. The slabs were built with a camber of 1 in., and showed no deflection under dead load. In the floors above the exchange floor this octagonal bay slab is the regular combination reinforced concrete and tile construction carried by intersecting girders, as shown in Fig. 3.

The floor covering in the guests' rooms is a 2-in. layer of cinder concrete, in which all pipes and wires are embedded, and which is covered with a 1-in. finishing coat of cement mortar troweled smooth, with rounded fillets at the wall angles. In the rooms devoted to public purposes the cinder concrete has embedded nailing strips, to which is attached a board flooring.

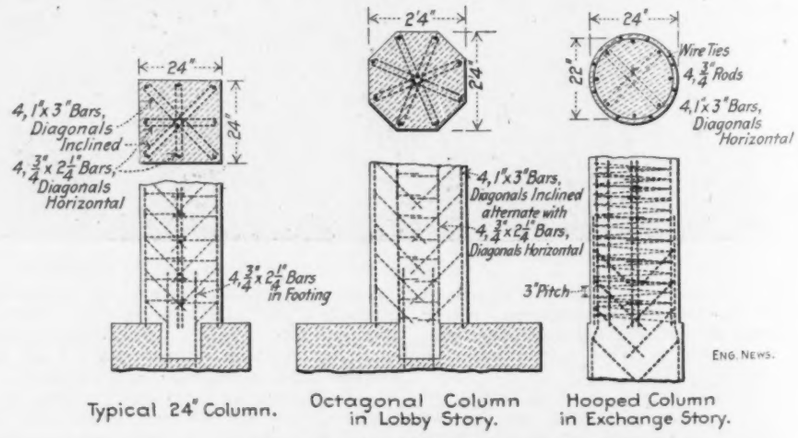


FIG. 2. DETAILS OF COLUMNS.

WALLS.—The exterior walls are independently supported for each story by the reinforced concrete wall girders, exactly as is done in steel skeleton frame buildings. The first story wall is granite ashlar masonry, and is carried by the beam footing previously described. The walls for all stories above the first are hollow tile laid up

building ... completed will cost about $1,000,000. The architects are Prince & McLanahan, Philadelphia, Pa. The structural design and details were worked out by Mr. B. J. Greenhood, of the Truscon Concrete Steel Co., Detroit, Mich. The tile ... manufactured and furnished by the National Fireproofing Co., New York, N. Y., and the same company had the contract for the construction of the entire building except the finish.

SPECIFICATIONS FOR AN ENGINEER'S TRANSIT AND LEVEL.*

By L. S. Smith,† Assoc. M. Am. Soc. C. E.

The knowledge of what constitutes a good transit for topographical work seems to the writer so important that for several years he has made the study of those instrumental errors which spring from unsuitable design and the laboratory work necessary for their detection an integral part of the required work of his surveying classes. In fact, part of the data upon which the criticisms in the present article are based, including tests of 60 field instruments belonging to the University of Wisconsin, was secured by his students in their regular work referred to. Let us inquire, then, what are the features of the usual complete engineer's transit or tachymeter which are most open to criticism, and what are the proper remedies.

It is the writer's observation that the performances of the vertical circle and of the telescope level fall far short of what reasonably should be expected, and thereby greatly limit the usefulness of the transit as a topographic instrument. The causes of this deficiency may be stated as follows: Too small a vertical circle, non-sensitive plate levels, the omission of a sensitive level from the vertical circle for the control of its zero, and the use of irregular and non-sensitive telescope level vials.

It is a well-known fact that an error of several feet in the horizontal location of a topographic point would scarcely be discernible on a contour map of ordinary scale, while an equally large error in its vertical location might entirely vitiate the map for its designed purpose. In view of this fact, the time honored custom of using transits with large horizontal circles, frequently reading to fractions of a minute, results simply in strengthening the work at a point already the strongest, while the custom which sanctions the use of small vertical circles weakens the work at a point where the greatest accuracy is needed. Even with a transit provided with horizontal and vertical circles of *equal size*, the elevations will still constitute the weakest part of the work. The usual excuse for the common practice of furnishing transits with smaller vertical than horizontal circles is found in the supposed danger of injuring the larger sized circle. The writer's experience under the most trying circumstances, incidental to rugged mountain climbing, would indicate that this danger is greatly overestimated. In fact, if the circle is protected with a cast metal guard (and it always should be so protected), there can be little danger.

A good compromise solution of the problem, provided the engineer is willing to forego a complete vertical circle, is found in a device described by W. L. Webb,* consisting of a short arc of very large radius provided with two verniers whose zeros are exactly 60° apart. The graduated arc, attached firmly to the telescope axis, is numbered in two rows from 0° to 60° each way. For elevated reading (plus) the right-hand vernier is used, while for depression (minus) angles the left-hand vernier is read. Such a device readily allows of an arc of 7 ins. in diameter, which would insure ease and certainty of its readings to half minutes.

Whether an arc or a circle be furnished, its vernier should be provided with an accurate and easy method of adjusting the zero. Few American transits are so provided. The usual detail is primitive indeed.

One objection to the substitution of the vertical arc for the complete circle is, that it precludes the reversion of

*From "The Wisconsin Engineer," December, 1905.
†Associate Professor of Topographic and Geodetic Engineering, University of Wisconsin, Madison, Wis.

*"Some devices for increasing the accuracy or rapidity of surveying operation." Trans. Am. Soc. C. E., Vol. XLVIII., 1902.

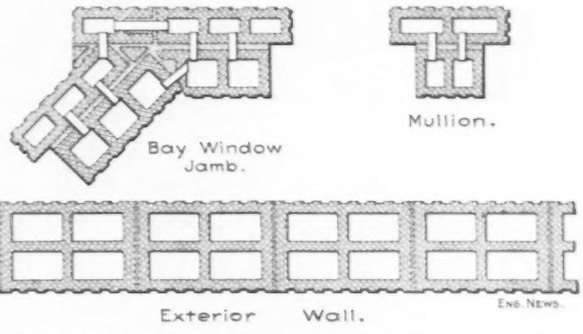


FIG. 7. DETAILS OF HOLLOW TILE WALL CONSTRUCTION.

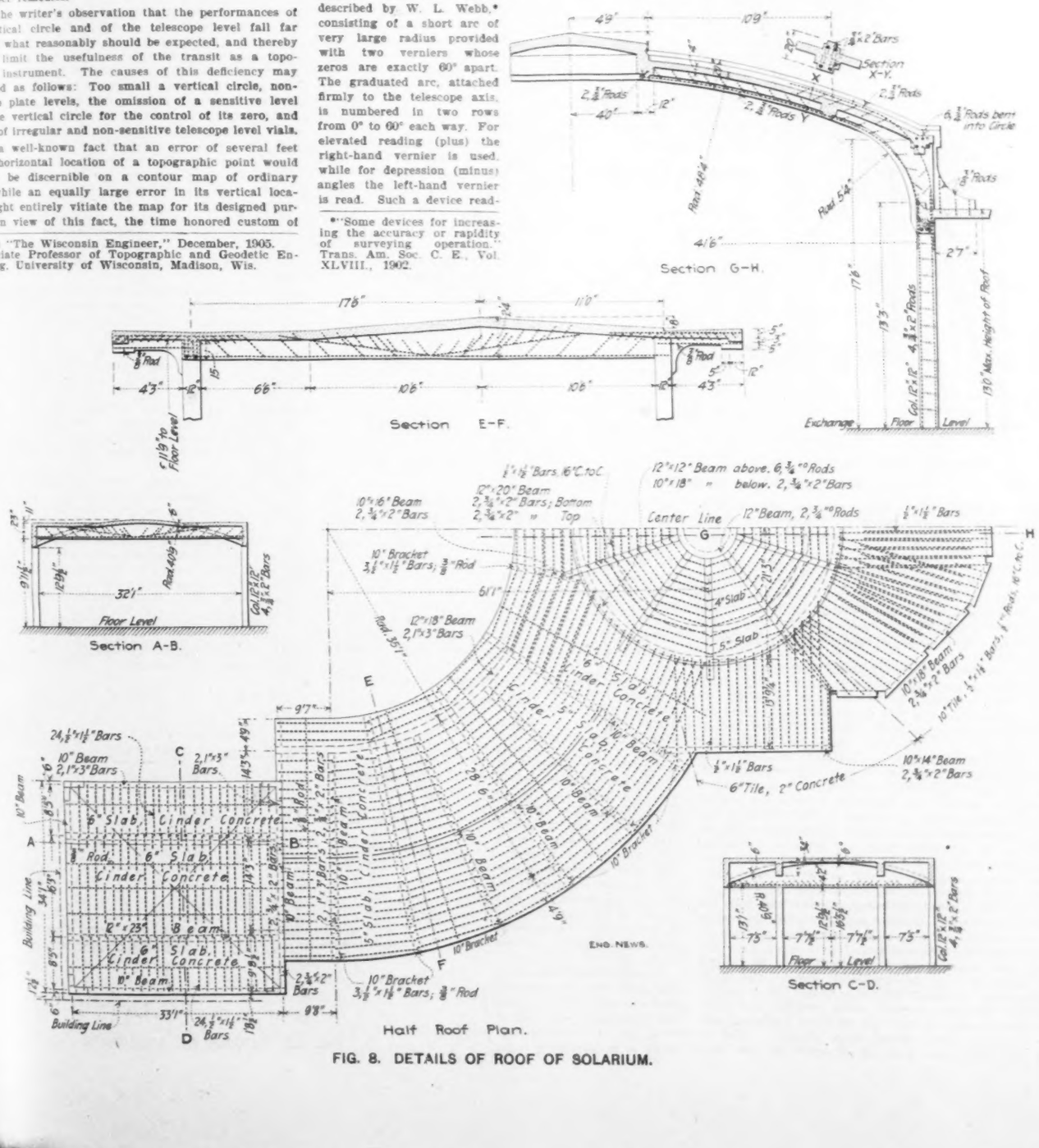


FIG. 8. DETAILS OF ROOF OF SOLARIUM.

of reinforcement, and give all essential dimensions.

All roofs were designed for a live load of 30 lbs. per sq. ft., using the same unit stresses for concrete and for steel as were used in the floor work. The notable feature of their construction is the use of stone concrete for all stiffening ribs, rafters, etc., and of cinder concrete for the slabs. The object of the cinder concrete slab construction was twofold; it reduced the load on the supports, and it gave a material to which the roofing tiles could be nailed directly.

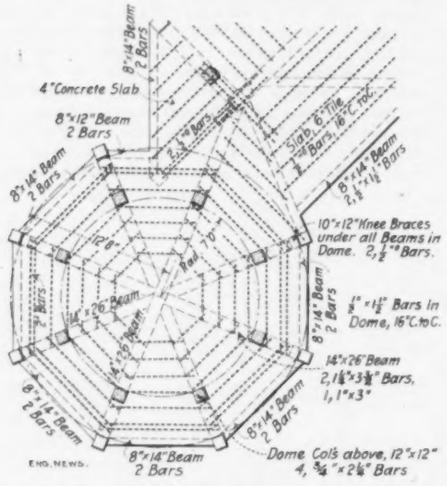

4"Concrete Slab
8"x12"Beam 2 Bars
8"x14"Beam 2 Bars
10"x12"Knee Braces under all Beams in Dome. 2, ⅞" Bars.
⅝" x 1½" Bars in Dome, 16"C.to C.
14"x26"Beam 2, 1⅛"x3½" Bars, 1, 1"x3"
Dome Cols above, 12"x12" 4, ¾"x2¼" Bars
8"x14"Beam 2 Bars
ENG. NEWS.

Fig. 4. Girder and Column Layout in Small Towers at Eighth Floor.

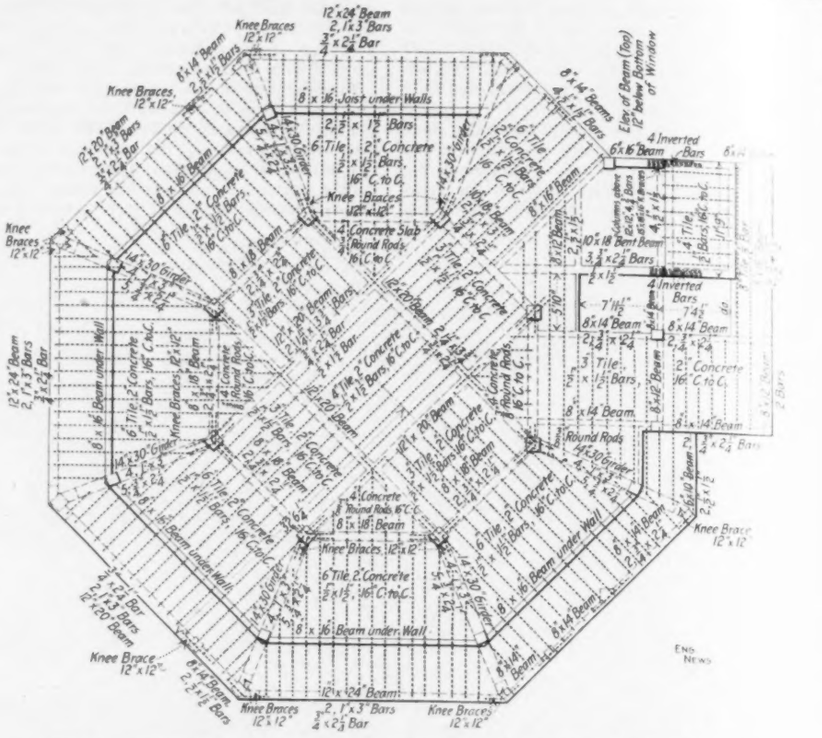


FIG. 5. GIRDER AND COLUMN LAYOUT IN NINTH FLOOR OF MAIN TOWER.

MISCELLANEOUS DETAILS.—Besides the more general details described above, there are a great many special structural details. Among these may be mentioned numerous girders that form footings for columns. Some of these are illustrated in Figs. 4 and 5. A more important example is the girder carrying column 104A; this girder is 18 x 40 ins., and connects two columns 24 ft. apart in the story below. In each end of the rear wing a pair of first story wall columns carries a girder which supports at its center a 2 x 2-ft. wall column, six stories high. These girders are 24 x 42 ins. in section, and have a clear span of 8 ft. Most of these special girders are knee-braced to the columns supporting them, as is indicated in Fig. 4.

The stair construction is all reinforced concrete. All stairs consist of a solid slab plain on the underside, and having its upper side notched to form the steps. Landings between flights are of the same type of construction as the floors, reinforced concrete and tile. The most important of the several staircases is that leading from the lobby floor to the exchange floor; it occupies, with its landings, six sides of an octagon, and encloses a central well.

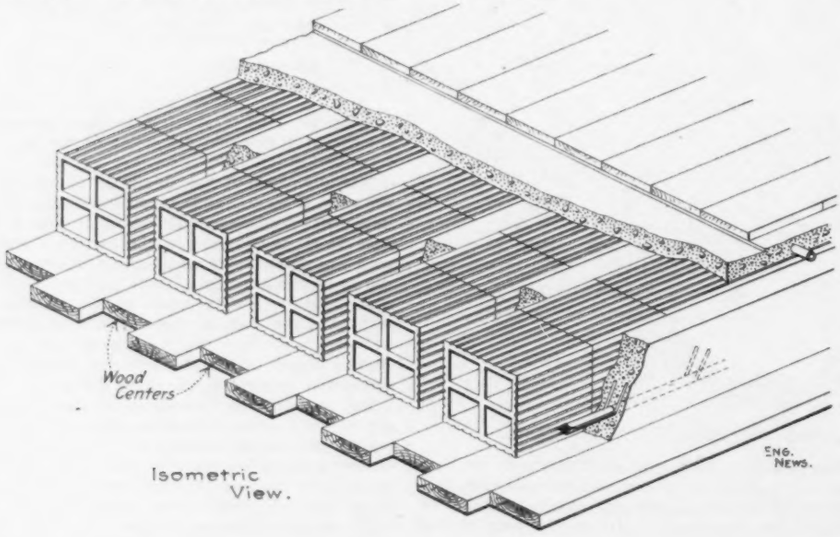
At the floor lines of the first to the fifth stories there are numerous exterior balconies projecting from 2½ ft. to 6 ft. from the walls; the plan Fig. 1, shows the location of certain of these balconies, and the drawings of Fig. 10 indicate clearly the several constructions employed. One of the constructions here shown is that for balconies for reaching the fire escape tower. This is located as shown in Fig. 1, and reaches from the roof to the lobby floor. It is a rectangular shaft, with concrete walls, having no opening directly into the building; at each floor, however, there is a balcony accessible by a door in the building wall, and another door in the tower wall. A flight of concrete stairs extends from top to bottom of the tower, with a landing at each floor.

METHODS OF CONSTRUCTION.—The methods adopted for carrying out the construction work call for mention in only a few particulars. Before taking these up, it should be noted in general that unusual pains were taken so to plan the work and equip it with plant that all operations would be facilitated to the greatest degree. The concrete was all mixed in two-batch mixers, and conveyed to the forms in wheelbarrows handled to the upper stories by elevators. The forms were framed on the site, a circular saw operated by electric motor being installed for cutting the timber to dimensions.

In construction the column and floor forms for an entire story were set up complete. The column molds were constructed as shown by Fig. 11; the particular feature is the rectangular yoke which slips over the form with a loose fit and is tightened by wedges. The girder forms are of the ordinary trough construction and are supported by the column forms and by intermediate posts, but the slab forms are of special construction. In place of the usual solid floor construction, 2 x 8-in. planks are laid with 8-in. spaces between. The tile fillers for the floor slab are placed so as to span the open spaces between planks and lap 2 ins. onto the planks at each edge. As shown by Fig. 12 the tile and plank together contribute a form for molding the ribbed slab.

The concreting was straightforward work; a rather wet mixture was used. Each floor contained about 30,000 sq. ft. of surface and was usually concreted in three days, while two weeks sufficed for completing a whole story, including the erection and eliminating of the forms.

ARCHITECTS AND CONTRACTORS.—The



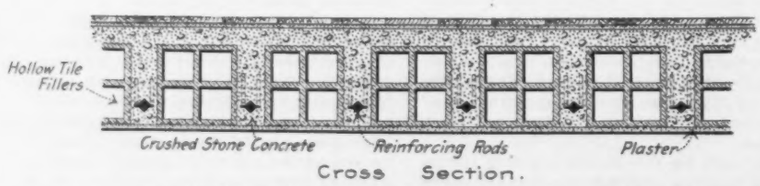


FIG. 6. COMBINATION REINFORCED CONCRETE AND TILE FLOOR CONSTRUCTION.

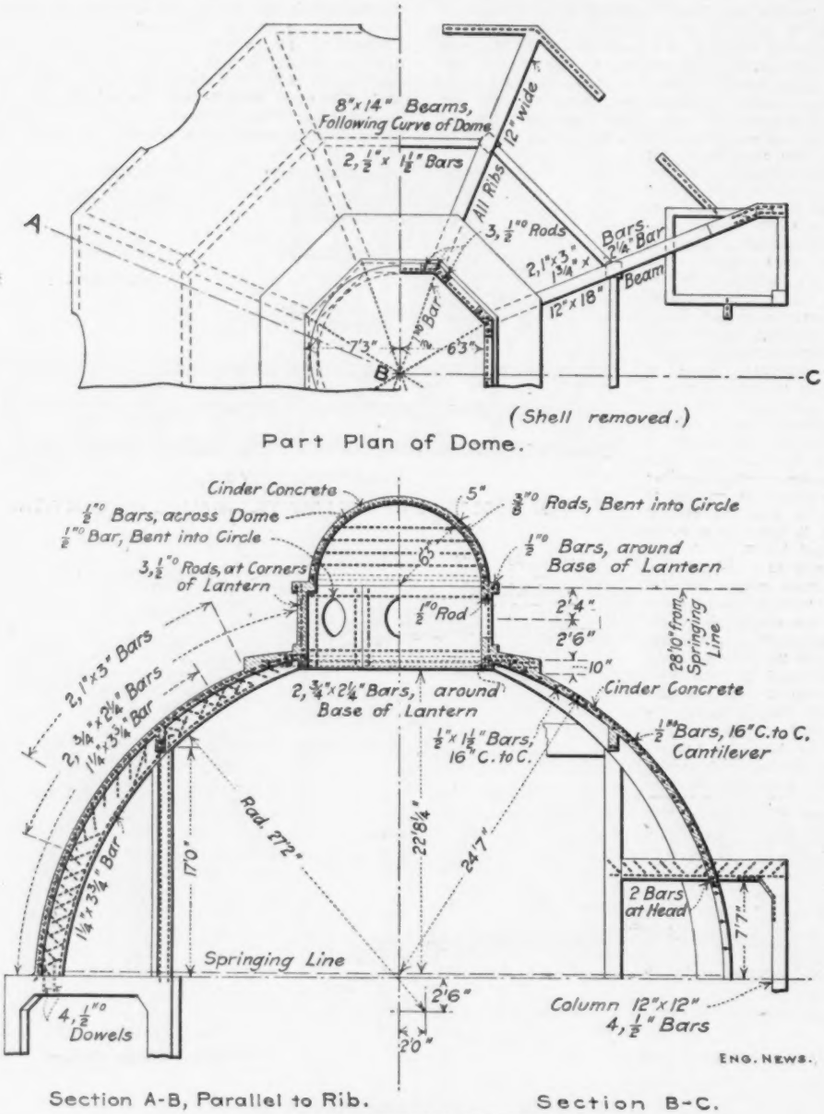


FIG. 9. DETAILS OF DOME FOR MAIN TOWER.

the circle for the elimination of errors of adjustment in such problems as, for example, the determination of azimuth by the direct solar observation, now so commonly used in the west.

Although the small vertical circles generally furnished by makers ostensibly read to single minutes, experienced observers are well aware that this accuracy is seldom realized, because of the uncertainty of the reading. The vertical circles should be graduated to half degrees and should be provided with permanently mounted magnifying glasses.

A second element which introduces error into the vertical work of a transit is the common practice of depending upon cheap non-sensitive plate levels for the control of the vertical circle zero. If not specified, makers send out plate levels with a sensibility between 100" and 360" of arc per 0.1-in. of level-tube. Now every topographer knows that after the orienting backsight has been taken and before the foresight can be taken, the instrument will get out of level, a condition indicated by the plate bubbles getting off center. This introduces errors in the vertical circle readings, it may be of equal angular amounts. Nor can the plate levels be releveled without increasing the error in the orientation which will affect all subsequent azimuths. But even if this displacement does not always take place, a sensibility of 100" to 360" is quite inadequate to control the vertical circle. The proper remedy for this evil is found by placing an extra level upon the vertical circle guard, to which is also attached the vertical circle verniers. The vertical circle guard is made to rotate about the horizontal axis of the telescope by means of a slow motion screw, s, so placed as to be difficult of confusion with the gradienter screw. The extra bubble on the guard is first adjusted to a central position when the vertical circle verniers read zero, the line of sight of the telescope being horizontal and the telescope level bubble being central. Now if the horizontal plate gets out of level the true vertical angle to any point can still be read by simply turning the slow motion screw controlling the guard until the extra level bubble comes to the center of its tube. The vertical circle reading is now the true vertical angle. The American makers usually charge $10 for this extra level and slow motion screw.

The writer would advocate two double verniers on the vertical circle even if the second vernier is used only to check eccentricity. The entire vertical circle should be protected by the guard, the verniers being covered by glass windows, the same as the verniers on the horizontal limb.

A further suggested change in the construction of the telescope is; more suitable provision for making the optical center of the object glass describe a straight line coincident with the geometrical axis of the telescope. This requirement is often not met, and yet without it the other specifications will fail to insure accurate work; the most frequent causes are, first, too short an object glass slide, and second, imperfect or inadequate fitting of the movement. This point is discussed more fully further on in this article, under the head of wye level.

Another needed change in the design of the transit, and one certain to improve the accuracy of its vertical work, is a rational increase in the sensibility of its telescope level. Except in very mountain[illegible] a properly run topographic traverse by the [illegible]-and-stadia method allows a considerable propo[illegible] of the vertical angle readings on turning points to [illegible] placed by level readings, thereby reducing the a[illegible] of required office work, and at the same time [illegible] a higher degree of accuracy in the resulting [illegible]. This would be notably the case in a comb[illegible] hydrographic and topographic survey of a river [illegible] adjacent valley. The point was first brou[illegible] the writer's attention while making a survey [illegible] rado River for a distance of about 25 [illegible] near Yuma, Arizona. At this point the river [illegible] in a wide sandy valley of light gradient, so that [illegible]tically all elevations were taken by level readings*. Although this survey was executed under the most trying conditions of weather, and with an average length of sight of about 1,000 ft., its levels checked on bench marks determined by accurate spirit leveling within about one-half a foot. Equally close results have since been observed on topographic lines, which leads the writer to the conclusion that a properly devised level on the transit telescope is quite sufficient to secure results under favorable circumstances comparable to that of common wye levels, and expressed by the formula: Error = 0.05 ft. × the square root of distance in miles as the lower limit, and perhaps twice this for upper limit, the latter being expected only under very unfavorable circumstances of length of sight and weather conditions.

If the above statement of the accuracy of transit levels be accepted as true, and a fast increasing number of topographers are accepting it, the field for the engineers' wye level is small indeed. However, such high-grade work cannot be expected with transits furnished with the non-sensitive and irregularly-ground levels so frequently furnished the unsuspecting purchaser. After considerable experimental work to determine this point, the writer would suggest a sensibility corresponding to: One-tenth inch = 15" to 20" arc. Of course the sensibility of the levels and the magnifying power of the telescope are inter-related.

Other important features of the engineers' transit, in which the requirements of rational design are not always complied with, may be considered under the heads: Magnifying power, Chromatic and spherical aberration, Definition, Flatness of field, Illumination, Centering of lenses. The limits of this paper will allow only a very general treatment of the above points.

Preliminary to testing a transit, the owner would do well to look carefully into the telescope barrel through the objective in order to discover the presence of an interposed diaphragm, sometimes inserted by the maker to prevent the discovery of the many evils resulting from poor lenses and poor workmanship. Such a diaphragm should never be tolerated, because it must reduce the effective diameter of the objective correspondingly, and thereby seriously interfere with its function as a light gatherer. The presence of such a diaphragm may always be taken as prima facie evidence of poor workmanship, *unless inserted near the reticule.*

For the land surveyor's transit the magnifying power has been considered sufficient if a movement of the alidade corresponding to the least count of its vernier causes an easily perceptible movement of the line of sight on the object sighted. For stadia readings this is not sufficient since the characters on the rod must be accurately read. As the diameter of the objective largely

*A Brandis Son & Co.'s light transit with sensitive level was used. See also for a discussion of such survey, Journal of the Assn. of Engineering Societies, Vol. 14, page 219, by J. L. Van Ornum. See also Engineering News, Aug. 31, 1905, for valuable report on "River Profile Work of the U. S. Geological Survey, Kennebec River, Maine, by Prof. A. D. Butterfield and G. M. Brett.

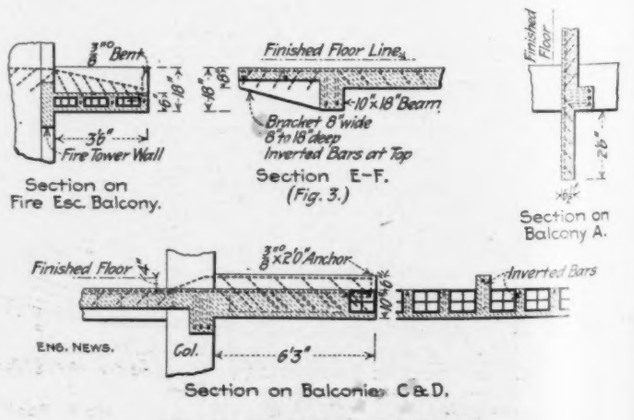


FIG. 10. DETAILS OF BALCONIES.

determine illumination of the image, it should be as large as possible, consistent with other details.

However, it must not be forgotten that a high magnification is at the expense of the size and brightness of the field. The loss of brightness must be compensated for by providing a larger objective. As this in turn makes necessary a longer telescope, the resulting height of standards required to allow the telescope to "transit over" limits the size of the objective. This difficulty can be largely overcome by the use of an *inverting eye piece.* The writer is well aware that in advocating an inverting

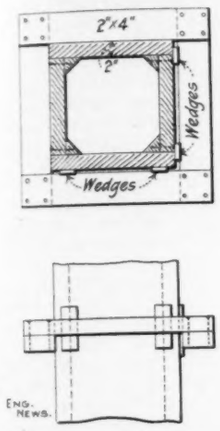


Fig. 11. Form for Columns

eye piece he is opposing the usual custom of this country. The opposition to the inverting telescope rests mainly on prejudice. A thorough trial of the inverting eye piece is certain to win a convert. The most important advantages of this eye piece are the increased brightness and distinctness of the image and the fact that it allows of a shorter telescope, thereby insuring a more rigid and compact instrument.

The flatness of the field depends largely on the sphericity of the eyepiece. This may be tested as follows: Draw a heavy lined square eight inches on a side, and place it at such a distance from the instrument that it shall nearly fill the entire field. When the telescope is focused its sides should appear perfectly straight, though a slight curve at the extreme limits of the field would cause no appreciable error in stadia work.

The definition of a telescope depends upon three conditions, the accuracy of the curvature of the various lenses, upon their centering and upon their movement in focusing. If the eccentricity of the eye piece is large or if the optical axis of the lens be not parallel to the line of sight, the definition may be so poor as to seriously affect the focusing of the extreme stadia wires. Displacements of the objective are even more serious in producing poor definition of the image. Lateral displacements of either eye-piece or objective may be discovered by taking the telescope of the transit out of the standards, and, after focusing the threads and objective on some distant point, turn the telescope in improvised wooden wyes. The image and the threads will appear to move in the arc of a circle about the telescope axis even when the wire or reticule adjustment has been perfectly made. Not infrequently makers send out even wye levels whose lenses, when tested as above, show very large eccentricities. Such an instrument should be promptly returned to the maker.

During the past nine years the University of Wisconsin has purchased about 45 transits and levels for the use of the rapidly increasing number of students in the engineering college. Thinking that the specifications under which these instruments were in most part purchased would be of interest to the reader, they are here given in full. It may be remarked that the custom of purchasing instruments by competitive bids and of allowing each bidder to write his specification is obviously unfair to all concerned. Besides making all bids comparable, carefully drawn specifications should insure the purchaser receiving exactly what he proposed to buy. Surely the specifications of so important a part of the field engineer's outfit as his transit and level should receive at least as much thought and care as is given to the purchase of a thirty-five dollar bicycle. That this care and caution is often entirely lacking is alike discreditable to his professional knowledge and his business skill.

SPECIFICATIONS FOR COMPLETE ENGINEER'S TRANSITS TO BE FURNISHED TO THE UNIVERSITY OF WISCONSIN.

General Conditions.—All constructive details shall be of superior workmanship and design. Weight not essential to the stiffness of the instrument shall be avoided by the standard rib construction. The instrument without tripod should weigh not more than 10 lbs. Especial attention shall be given to making extra strong all parts likely to be injured by accident. Only the hardest bell metal and phosphor bronze shall be used for centers and telescope axis, and soft brass shall be everywhere avoided. Tangent screws and head of tripod shall be made of aluminum bronze and provided with German silver spiral springs. Prices shall be f. o. b. Madison, Wis.

Horizontal Circle.—The diameter at the edge of graduation shall be 5 ins. The graduation shall be to half degrees on solid silver, frosted finish, and every ten degrees shall be distinctly numbered from zero to 360 in both directions, the numbers sloping in the direction they are increasing.

The circle shall be provided with two double verniers, A and B, exactly 180° apart, and reading to single minutes.

The zeros of the verniers shall be placed at an angle of 35° to the line of sight, and shall be provided with ground glass reflectors. Eccentricity of vertical axis and of all verniers must be as perfectly eliminated as the highest mechanical skill will allow.

Vertical Circle.—Transit shall be provided with a complete vertical circle with a diameter not less than 5 ins., graduated on solid silver and read to single minutes by two double verniers. The verniers shall be provided with an easy and reliable means of adjustment. The vertical circle shall be furnished with a cast metal guard to protect the entire edge of the graduation. An extra level vial, sensibility 0.1 in. = 20″, with suitable means of adjustment, shall be firmly mounted on this guard so as to control the zeros of the verniers. The horizontal axis shall have a radial clamp and slow motion screw with a gradienter.

Magnetic Needle.—Instrument shall be provided with the usual compass box and a sensitive and accurate needle about 3½ ins. long.

Telescope.—The objective shall have a clear aperture of not less than 1⅝ ins. diameter, perfectly achromatic and with a flat field, suitable for accurate stadia measurements. Both the objective and ocular lenses shall be mounted so that their optical centers lie in the geometrical center of telescope tube, and provision shall be made to insure that the optical centers shall describe straight lines when focused.

The eye-piece shall be inverting, magnifying between 22 and 28 diameters, and be free from chromatic aberration. It shall also be provided with a prismatic eye piece with a solar shade. The regular eye piece shall have the usual focusing screw or worm and a dust guard.

Horizontal Axis.—Shall be provided with the most improved means of adjustment and shall be fitted with a suitable base for the attachment of a Saegmüller solar attachment.

Stadia Wires.—Two extra fixed stadia wires, very fine and opaque, shall be furnished and placed equidistant from the middle crosswire. The total distance apart of the stadia wires shall be 1-100 of the focal length of the objective. They shall be of such size as not to cover more than 0.02 ft. on a rod held at a distance of 1,000 ft.

Telescope Level.—The level shall be ground to a uniform curvature of 0.1-in. = 20″ to 25″. The graduations shall extend over the entire exposed length and shall be numbered on the vial both ways from zero at the center.

Plate Levels.—Both plate levels shall be accurately fixed to the transit with the most approved and stable provision for their adjustment. Both levels shall be graduated and their curvature shall be 0.1-in. = 40″.

Clamps.—The heads of all clamps shall be one-third smaller than usual pattern to prevent injury from inexperienced hands.

Finish.—The telescope, telescope level, vertical circle guard, and standards shall have the so-called "cloth finish," the remainder any good standard finish.

Tripod.—Shall be of the split leg pattern and provided with shifting center. Its weight shall not exceed seven pounds. The steel shoe of tripod shall be provided with a shoulder for forcing it into the ground.

Box.—The instrument shall be furnished in a neat hardwood box with lock, together with a sun shade, reflector, magnifying glass, plumb bob, wrench, adjusting pins, and silk or waterproof bag. The box shall have a leather strap, and rubber cushion on the bottom, and shall be so constructed as to allow of transit being packed flat instead of upright.

ENGINEERS' LEVELING INSTRUMENTS.

A discussion of the relative merits of "wye" and "dumpy" levels is aside from the main purposes of this paper, and yet it may not be out of place to briefly state the writer's views on this point. The American engineer is clearly behind his European brother, who has long recognized the merits of the dumpy type of leveling instruments. The greater steadiness claimed for the wye level is more than offset in the dumpy level by its simplicity of construction and adjustment, with the resulting certainty of the relation between the line of sight and the axis of the level vial. The supporters of the wye level have little ground on which to stand. The most perfectly constructed leveling instrument ever made, both from the theoretical standpoint as well as evidenced by its completed work, is the latest type of precise level designed by the U. S. Coast and Geodetic Survey. This level is of the dumpy type. With it 250 miles of single level lines have been run per month, and that too with greatly increased accuracy over that claimed for commercial leveling.* The merits of the dumpy level are already proved and its general use will be delayed only by the difficulty of "teaching old dogs new tricks."

WYE LEVEL.—The following brief discussion includes the important points in the specifications for a wye level used at the University of Wisconsin.

1. Telescope.—(a) The object class should have a clear aperture of not less than 1⅝ ins. and should have the other requisites given in the discussion of the transit. It is doubly important in the level that the object glass be so securely and accurately mounted that when focused at different distances its optical center shall describe a straight line coincident with the geometrical axis of the telescope. Any wobbling is fatal to accurate work. Stable conditions can be best secured by the use of long object glass slide, extending nearly to the reticule. In general it appears that this detail is most often slighted by the makers.

(b) It is imperative that the diameters of the rings or collars should be the same, if the axis of the bubble is to be made parallel to the line of sight by the "indirect method." The possibility of making the above adjustment by the indirect method is sometimes given as one of the arguments for the use of the "Wye" level, and yet if the diameters of the rings differ by 1-5,000 part of an inch the resulting error in a rod reading 300 ft. distant would amount to about .01 ft. even when the instrument appeared to be in perfect adjustment.

(c) The eye piece should be inverting, magnifying 35 diameters, and protected by dust shade.

2. Level Vial.—The level vial should be carefully ground to a uniform curvature of 0.1-in. equal to 8″ to 10″ of arc. The graduations should be etched on to the bubble tube itself and not on an attached scale as is frequently done.

3. A clamp and slow motion should be provided to the vertical axis.

Tripod specifications are similar to those of the transit with this addition: The accuracy of any work is in large measure dependent upon the mental state of the observer. If he can observe in a comfortable position in the long run his work will show an increased accuracy over that performed under uncomfortable circumstances. For this reason it would be well to have the length of the tripod legs increased so that the engineer could observe in a nearly upright position. If a tripod be provided like that of the U. S. C. & G. S. precise level, no unsteadiness will result from this increased length.

The cloth finish should be specified on telescope and level vial.

Frequently it would be convenient if instrument-makers would provide interchangeable tripods so that both the transit and level would fit on same tripod.

DUMPY LEVEL.—The only modifications in the specifications, to fit the dumpy level, would be to decrease the magnifying power to 30 diameters and the sensibility of the level vial to 0.1-in. = 12″ to 15″. The eye piece should be inverting. The small extra charge for the clamp and slow motion to the vertical axis is well worth the cost. The university has paid $75 for the above described instrument. The average accuracy of the leveling work done at the university by sophomore students is 0.035 ft. multiplied by the square root of the distance in miles. This is the error determined by the closure of circuits about 5 miles long.

The present type of "dumpy" level made in this country would be greatly improved by the adoption of some of the improvements made on the new U. S. Coast and Geodetic Survey precise level. Briefly stated these are as follows:

(a) A micrometer for making the final pointings of the line of sight after the level is approximately level.

(b) Inserting the more sensitive level vial in the top of the telescope and as near to the line of sight as possible.

(c) The use of a reflector which will allow a view of the level bubble at the same time as the rod reading is made.

THE NEED FOR SPECIFICATIONS.

That there may be no doubt in the reader's mind regarding the need of definite specifications similar to the foregoing, it may be said that, before this plan was adopted at the University of Wisconsin, the instruments bought were seriously lacking in important details. For example, one of the oldest and best known American firms furnished a transit whose telescope level had a sensibility of 0.1-in. = 72″ (about suitable for a hand level!), and whose plate bubbles had a sensibility of 0.1-in. = 360″. Though the horizontal circle of this instrument is nearly *seven inches* in diameter, the vertical circle furnished has a diameter of only *four inches.*

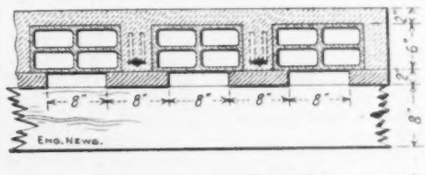


Fig. 12. Form for Floor Slabs.

The results obtained by this instrument have shown a uniformly larger error than that attained by the standard instruments purchased under the above specifications.

A comparison of the plate bubbles of ten similar instruments, purchased simply by catalogue number, shows that not only do different firms use widely different levels on the same grade of instrument, but even the same firm does at different times; the range on plate bubbles being from 40″ to 360″, and on telescope levels from 8″ to 72″ per one-tenth inch division. The con-

*See Eng. News, July 2, 1903, for an article by J. F. Hayford, on this subject, giving the experience of the U. S. C. & G. S.

clusion, that makers frequently use whatever they happen to have in stock, quite regardless of suitability, seems warranted by the facts.

Some will not fail to urge the impossibility of buying a transit at a reasonable price under such rigid specifications as suggested above. In answer it can be said that the average price paid for a transit under these specifications has been considerably less than formerly (without specifications). The present year the lowest bid, from an American maker, was $175 per transit. The University owns several transits made by this maker, and severe field tests have shown them the equal of any both in accuracy and durability. A transit purchased of a German firm, this season, cost, delivered in Madison, about $136, being admitted duty free. This instrument would cost about $225 in this country. Repeated tests of this type of instrument have shown it equal both in accuracy and durability to any made in the United States.

THE SANDY BAY BREAKWATER, NATIONAL HARBOR OF REFUGE, CAPE ANN, MASS.

The United States Government is building a breakwater at Sandy Bay, Cape Ann, Mass., which upon completion will rank as the most extensive structure of its kind in the United States, so far as depth of water in which it is built, size and cost are concerned. This breakwater will form a national harbor of refuge, whose location is, beyond a doubt, unequalled by any between Boston and Portland. The harbor will have good holding ground and will always be free from ice. It lies directly in the track of the Eastern coasting and fishing trade, at a point where a very large number of vessels annually pass. The harbor will have great accessibility in the day time, in weather when the adjacent coast can be seen.

DESCRIPTION OF SANDY BAY.

Sandy Bay (Fig. 1) is situated at the northeastern extremity of the promontory of Cape Ann, which forms the northern limit of Massachusetts Bay, and is formed by a rectangular indentation in the high rocky shores of Cape Ann. The shore lines form a little less than a right angle, and their directions are nearly north and south and east and west. The rocky island of Straitsmouth forms the eastern extremity of one shore line and the steep headland of Andrew's Point the northern end of the other.

The adjacent vicinity is covered with hills of syenite. In these, extensive quarries have been opened, from which the production of building stone constitutes the most important commercial interest in the town of Rockport and its vicinity.

Sandy Bay is about 2¾ miles by 2 miles in area and is fully protected on the west and south by high hills, but fronts the northeast and is open to the full effects of easterly and northeasterly gales. The violent and dangerous winds in this part of the Atlantic blow from the directions named and are accompanied by heavy seas.

The axis of the bay lying about northeast, its whole expanse is open to the full effects of the most violent gales. The great seas rolling in from the Atlantic are, however, broken to some extent by the sunken rocky ledges, called Avery's Ledge, the Dry and Little Salvages, the Flat Ground, and Abner's Ledge, which are directly at the mouth of the bay. They form a slight but insufficient protection for the deep and capacious anchorage ground lying to their westward, which has an average depth of 50 ft. at mean low water over an area of about 1,300 acres, the underlying bottom inside the above mentioned sunken ledges being sand mixed with mud, thus affording excellent holding ground.

The southern entrance to the harbor lies between Straitsmouth Island and Avery's Ledge, and is to be 1,800 ft. wide and at least 30 ft. deep. The northern entrance, near Andrew's Point, is 2,700 ft. wide and 80 ft. deep. These entrances are so located with reference to each other that vessels can enter and leave the harbor with any wind.

ORIGINAL PROJECT.

The subject of an extensive national harbor of refuge between Boston and Portland has been under consideration since 1882, in which year Congress provided (River and Harbor Act, Aug. 2, 1882) for an examination and survey of Sandy Bay, with a view of a breakwater for a harbor of refuge. The first report on the subject, with a view to the construction of a breakwater for a harbor of refuge, was made by Bvt. Brig. Gen. Geo. Thom, Colonel of Engineers, U. S. Army, under date of Oct. 7, 1882, in which Colonel Thom stated that this bay was worthy of improvement and the work a public necessity. This report was based upon a preliminary study, made upon a map of the Coast Survey.

Under date of Nov. 28, 1883, Major Chas. W. Raymond, Corps of Engineers, U. S. A., submitted a report of a survey on this same subject. Major Raymond recommended a location for a proposed breakwater, starting from Avery's Ledge, where the mean depth of water is 11 ft., thence extending in a northerly direction a distance of 3,000 ft. to Abner's Ledge, then curving to the westward 1,200 ft., then in a northwestwardly direction 4,800 ft., the proposed breakwater having a total length of 9,000 ft., and consisting essentially of two branches.

Along the southern branch, between Avery and Abner ledges, the average mean low water depth

Fig. 1. Map Showing Location of Sandy Bay Breakwater and Harbor of Refuge, Cape Ann, Mass.

is only about 45 ft., while along the western branch the mean low water depth is about 65 ft., the maximum depth being 89 ft.

The essential features of the proposed breakwater (see Figs. 2 and 3) were:

(1) A solid conical pier of masonry on Avery Ledge, the diameter at top being 30 ft. and at bottom 45 ft., and a similar but smaller pier at the western end of the breakwater.

(2) A substructure consisting of an enrockment formed by dumping granite rubble from barges, the smallest rubble placed in the core, the medium-sized placed in the inner layer and the largest on the outer covering.

This arrangement was intended to increase the volume of the voids, and thus diminish the amount of stone required for the enrockment. The upper surface of the substructure was to be 15 ft. below extreme low water. This depth at that time was considered the limit of the effective action of the sea, the adopted project for the Delaware Breakwater, placing the base of the superstructure only 12 ft. below mean low water.

(3) A superstructure consisting of a masonry wall formed of very large stones, laid up dry below water, and above low water a masonry wall laid in cement. The dry wall below water was provisionally adopted, pending further investigation, because of the great facilities for obtaining very large stones in the immediate vicinity, and because of the experience of the local quarryman in laying large stones under water.

The total cost of the breakwater was estimated to be $4,000,000. The breakwater, as proposed by the local engineer, was approved by a board of engineers, consisting of Col. Charles E. Blunt and Lieut. Cols. Wm. P. Craighill and Walter McFarland, Corps of Engineers, U. S. A., in reports dated Aug. 22 and Nov. 20, 1884, but its estimate of cost was $5,000,000.

In a report submitted by the local engineer, under date of Sept. 10, 1885, he stated that by investigation in the locality, and by the study of more recent experience in foreign harbors had become apparent that the limit of wave action heretofore adopted, 15 ft. below extreme low water, was altogether too small, and that it would not be safe to establish the foundation of the superstructure at a higher level than 22 ft. below mean low water. Under these circumstances it was considered that the plan for a dry masonry wall must be rejected, and some form of concrete superstructure was suggested. These recommendations were approved, and work upon the rubble substructure was commenced under contract in November, 1885 (see Fig. 4).

In the fall of 1892 the substructure between Avery and Abner ledges, and beyond, a distance of about 5,000 ft., was substantially completed, with its upper surface 40 ft. wide and 22 ft. below mean low water. About 538,000 tons of quarry-ranged rubble, at an average price of 67½ cts. per ton, were deposited in the structure. No work on the superstructure had been done.

Up to this time it was not discernible that any of the rubble had been moved by the action of the sea.

PROJECT OF 1892.

Under date of March 2, 1892, a board of engineers, consisting of Col. Wm. P. Craighill, Lieut. Col. S. M. Mansfield and Major C. W. Raymond, Corps of Engineers, U. S. A., submitted a report for a plan for substructure as well as superstructure for the *entire* breakwater proposed at Sandy Bay.

The board referred to the original project of a random stone substructure, carrying a masonry wall, which was proposed in order to save the great expense of carrying the rubble mass above high water, which involved the deposit of an enormous amount of material below the limit of the effective action of storms. The board was of the opinion that in the construction of such a structure the top width of the substructure should be 40 ft., and that the top should be 22 ft. below mean low water (see Fig. 4). It was also of the opinion that in the construction of the superstructure the only method likely to give reasonable promise of success was the method of sloping concrete blocks adopted at Colombo and Réunion.

The board, however, did not recommend such a construction, there being no precedent for the construction of an off-shore breakwater on the sloping block system. All the breakwaters built on this plan have started from the shore, and this fact has determined the character of the plant employed. Thus at Colombo, Madras, Mormugoa, Manora, Kustendjie and Réunion, the blocks were placed in position by large and costly overhanging balance cranes, which traveled on railways along the breakwater, and could be run in shore during seasons of exposure. The peculiar advantages of such machines would be entirely lost in an off-shore structure. The exposure of the site to the violent action of waves and currents, and the necessity of accurate adjustment imposed by the sloping block system, render the use of floating appliances entirely out of the question. A special plant would have to be devised, which would be experimental in character and doubtless very expensive. The leveling of the upper surface of the substructure for the foundation of the wall would have to be done by divers and would be slow, difficult and costly. The board therefore recommended as the best method of construction for the southern branch of the breakwater between Avery and Abner ledges the depositing of granite rubble in the manner as then in progress at the Delaware Breakwater. The mound was to have a width of 51 ft. at mean low water and to be formed up to that level by the deposit of random stone, so that the slopes should be such as might be established by the action of the sea, the heaviest stones to be placed on the exposed face of the structure. The superstructure, above low water, was to have a height of 18 ft. and a top width of 20 ft., with slopes of about 1 on 1 on the sea side and 1 on 73-100 on the inside, formed by the heaviest stones laid in position, the interior space to be filled with rubble. (See Fig. 4.)

For the western branch of the breakwater the board recommended the rubble mound proposed

for the southern branch, and also that a thorough investigation should be made of foreign practice, especially at the harbor of Boulogne, with a view to possible economy by the construction of a masonry wall above low water.

The project submitted by the board was based upon the fact that the country in the vicinity of Sandy Bay is covered with hills of syenite, containing extensive quarries, from which stone can be obtained at a low price. The rubble employed is the refuse of the quarries, and its removal

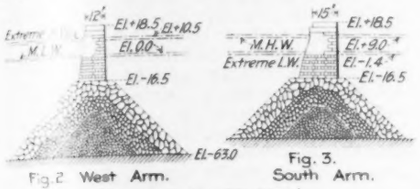
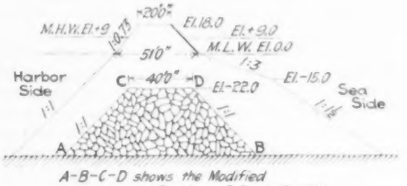


Fig. 2. West Arm. (Proposed Nov. 28, 1883.)

Fig. 3. South Arm.



A-B-C-D shows the Modified Section of Sept. 10, 1885

Fig. 4. Section Provisionally Adopted March 2, 1892.

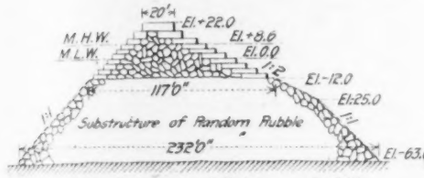


Fig. 5. Modification of February 13, 1900.

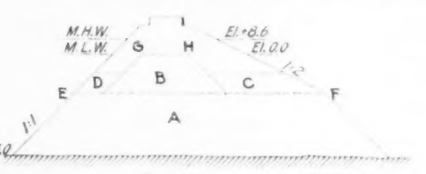


Fig. 5a. Eng. News.

FIGS. 2 TO 5. CROSS-SECTIONS, PROPOSED AND ADOPTED, OF SANDY BAY BREAKWATER, CAPE ANN, MASS.

has hitherto been a source of expense to quarry companies. It has been estimated that the four breakwaters built up from the shore near Rockport contain about 1,500,000 tons of this refuse material.

In the preliminary project the local engineer estimated the cost of the rubble in the breakwater at 70 cts. per ton. The actual contract prices paid for stone have been 58.3 cts. per ton in 1885, 71 cts. in 1886 and 1888, and 73½ cts. in 1891.

By 1898, 600 ft. at the northerly end of the southerly arm had been completed to full section, 1,200 ft. more had been carried up to low water, and 2,800 ft. more had been up to 22 ft. below low water.

The 600 ft. of superstructure was formed of stones weighing not less than four tons each, and averaging six tons, and the southerly 250 ft. of it had settled some 2 ft. In the early part of the year, in a storm of exceptional severity, the 600 ft. of completed superstructure was torn down to a height of about 5 ft. above mean low water.

PROJECT OF 1900.

The River and Harbor Act of March 3, 1899, in the item appropriating $250,000 for the improvements at Sandy Bay, provided that "the Secretary of War shall appoint a board of three engineers, whose duty it shall be to examine said project and report whether any modification of the same should in their judgment be made." The board was duly appointed and made two reports, one under date of July 3, 1899, the other dated Feb. 13, 1900. In the latter report the board was of the opinion that for the locality of Sandy Bay Breakwater the plane of quiescence, or the limit of the effect of wave motion upon such a structure, may be taken at 25 ft. below low water. Below this plane the substructure may be given a slope of 1 on 1 on both sides, which, in the opinion of the board, will be permanent at that slope. Above this plane the structure should have a slope of 1 on 2 outside and 1 on 1 inside, and should be 30 ft. wide at reference 17 above mean low water.

The board divided the superstructure and the substructure by a plane 12 ft. below low water. The part of the breakwater above this plane, to be referred to hereafter as the superstructure, should have its front and rear faces composed of selected stones, weighing not less than eight tons for the sea face, and three tons for the inner face, having the least dimension not less than one-fourth nor more than two-thirds of the greatest dimension. The stones in the two faces should be laid horizontal, with the longest dimension perpendicular to the axis of the structure. The top course, with its upper bed in reference 17, should be composed of stones of not less than ten tons, having the relative dimensions specified, no stone in the outer row to be less than 15 ft. long, and none in the inner row less than 10 ft. long; the tops to lie in the plane fair enough to receive the course of cap stones. The body of the superstructure between the faces described should be of similar stones as to size and shape, dumped at random. On the rubble crown at reference 17 there should be laid a row of quarry-faced cap stones, weighing not less than 20 tons each, approximately 3 x 5 ft. in end section, laid on edge and transversely in as close contact as possible; the sea ends to be in line about 5 ft. from the sea edge of the rubble crown; the substructure to have a sea slope of 1 on 2 to the plane 25 ft. below low water, and below that plane the natural slope; the inner slope to be 1 on 1 throughout.

The substructure should be composed of random rubble, no stone of which should weigh less than 200 lbs., and 50% of the stones should be of not less than two tons weight. (See Fig. 5.) No superstructure should be built on substructure that has been in place less than a year, and, if the exigencies of construction permit, a longer time should be allowed.

The estimated cost for completing the breakwater was as follows:

Substructure,	3,482,487	net tons	at	$0.65..	$2,263,617
Superstructure,	1,434,000	" "	"	2.00..	2,868,000
Cap stones,	74,865	" "	"	3.00..	224,595
					$5,356,213
Add for contingencies 10%					535,622
Total estimate					$5,891,833

Including what had been spent to that time, the total estimate for the work was $6,904,952.

difficulties of construction, and was therefore entirely feasible.

(2) That all argument heretofore advanced in support of the improvement can be repeated with emphasis at this time, in view of the steady growth of the coastwise trade during the past few years. For this and the further reason that the size and draft of vessels are steadily increasing to a point where many of them can no longer seek refuge in the smaller harbors along the coast heretofore used by smaller craft, the continuation of the improvement is deemed advisable.

(3) That no modification can be made in the project with a view of diminishing the cost.

(4) That no portion of it can be left off.

METHODS OF CONSTRUCTION.

The bottom section (A, Fig. 5A) is first formed by dumping the material within the limits of the crest line, EF, which is 25 ft. below mean low water, the stone being allowed to take its natural slope on either side. Section B is next formed, the dumping being again restricted to the crest width, GH, and the stone being allowed to take its natural slope. Section C is next deposited, the exterior slope of 1 on 2 being formed by placing large stones with the derrick. Section D is a small bench 17 ft. wide and 13 ft. high. No work is done on this until the laying of the facing blocks is about ready to begin. As yet none of the facing blocks comprising the superstructure have been set.

PRESENT CONDITION OF WORK.

On June 30, 1905, the condition of the work was as follows, reference being made to Fig. 6: The southern arm for a length of 3,530 ft. has been built up to a height of 12 ft. below mean low water, the base of the superstructure, with a top width of 117 ft.; the rubble core of the superstructure has been built to the height of mean low water for 2,990 ft., and to the height of 5 ft. above mean low water for 540 ft. Nothing has been done for 70 ft. at the end near Avery's Ledge.

In the western arm, for a length of 1,710 ft. from the angle (Sta. 36), the mound of rubble stone has been completed to the full height of 12 ft. below mean low water, and to the full projected width of 117 ft., except for a small bench on the inner slope 13 ft. deep and 17 ft. wide (see Fig. 5A; D). A rubble core of the superstructure 1,710 ft. long has been built, of which 1,310 ft. is up to the height of mean low water, and 400 ft. up to the height of mean high water.

The amount expended in the construction of this breakwater up to June 30, 1905, not including outstanding liabilities, is $1,350,043, with which 1,752,935 tons of rubble stone have been placed in the substructure of the breakwater, at an average cost per ton of 77 cts. Up to the above mentioned date, 37% of the total quantity of the rubble stone required had been deposited in the substructure.

Under date of June 21, 1905, a contract was entered into with the Federal Contracting Co., of New York City, for supplying 300,000 tons of rubble stone, at 60 cts. per ton of 2,000 lbs., a very material reduction from the average price.

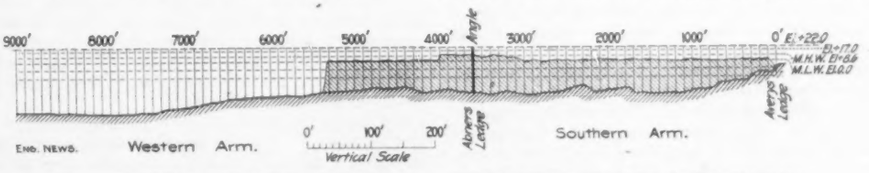


FIG. 6. PROFILE SHOWING AMOUNT OF RUBBLE STONE PLACED IN SANDY BAY BREAKWATER UP TO JUNE 30, 1905.

The River and Harbor Act of June 13, 1902, appropriated $200,000 for continuing the improvement, but provided that no part of this sum should be expended until a board of engineers had examined the project and reported upon the feasibility and advisability of continuing it to completion and the possibility of so modifying it as to reduce the cost. A board of engineers, consisting of Col. Chas. R. Suter, Lieut. Col. W. S. Stanton, and Major S. W. Roessler, Corps of Engineers, U. S. A., was duly appointed, and, under date of Sept. 18, 1902, reported as follows:

(1) That the project presented no insuperable

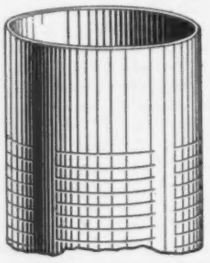
This article has been compiled from the annual reports of the Chief of Engineers, U. S. Army.

DRAINAGE OF EARTH ROADS is discussed by Prof. Ira O. Baker, M. Am. Soc. C. E., of the University of Illinois, in a circular recently issued by the Engineering Experiment Station of the University of Illinois. Prof. Baker favors a single line of tile drain, laid under one of the side ditches. For maintenance of the road surface he advocates the use of a drag made from a split log or steel rail, to smooth off the surface by breaking down ridges and filling ruts, in the spring of the year.

STRAINERS FOR DRIVEN WELLS.

By Dabney H. Maury,* M. Am. Soc. C. E.

For convenience, wells may be divided into two classes, open wells and driven wells. An open well is usually understood to be a well of a diameter so large that a man may enter it, and which has its shoe or bottom edge in the water-bearing stratum, and takes water from under the shoe. Large wells may be so constructed as to take water through openings in the sides of the shell, the bottom being either left open or sealed by resting in impervious soil, or closed artificially with concrete or other suitable material. This article will be confined to driven wells.†



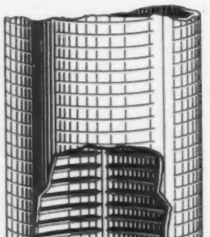


Fig. 1. Cook Well Strainer.

Driven wells are generally from 2 to 15 ins. in diameter, these sizes being about the practical limits of diameter of the wrought iron or steel pipes or casings forming the shells of such wells. If the well takes its supply from an underground reservoir in a cavity in durable rock, no strainer is required, and the lower end of the pipe or casing is left open.

Wells which draw from water-bearing sands or gravel are usually provided with some sort of well point or strainer, designed to hold back the sand or gravel while admitting the water. During the past half century many patents have been granted for well points and strainers. Most of the early patents covered well-points, some of which were fitted with large and tapering threads and were intended to be screwed down into the ground, while others had plain pointed ends, designed to facilitate driving. In either case the well was, as a rule, supposed to be so small as to admit of its being forced into the ground without the aid of the sand bucket or jet to remove the material from within the space enclosed by the casing. As the knowledge of the art grew with experience the practice of putting in large gangs of small wells was gradually abandoned, and the size of the individual wells was increased. When the driven well got too large to be driven down with a closed end, like a stake or a pile, it became necessary, in order to sink it, to remove the material from the space enclosed by the casing, either by the sand bucket, or jet, or some other means. This in turn called for a strainer which should be capable of being put into place after the well-casing had been sunk to the proper depth, the casing then being pulled back so as to uncover the openings of the strainer and allow the water to flow in.

The principles on which strainers are designed to operate, and their consequent construction, would naturally divide them into two classes, which for the purposes of this discussion will be termed fine strainers and coarse strainers.

Fine strainers are those in which the openings are so small as to exclude all, or nearly all, of the finest particles of sand to be found in the water-bearing stratum.

Coarse strainers have openings considerably larger than the finest particles of sand and gravel in the water-bearing stratum, but somewhat smaller than the coarsest particles. This latter construction contemplates the drawing in of the finer particles through the openings, by any one of a number of methods, and the subsequent removal of these particles by repeated pumping, so as to ultimately form, outside of the metal strainer proper, a greatly enlarged strainer area, composed of the mass of the coarser gravel adjacent to the strainer.

Practically all of the earlier well-points or strainers belong to the former or fine class. Usually an iron pipe with large perforations or slots was employed to give strength to the strainer and to act as a support for a wrapping of wire gauze or perforated sheet brass or copper. Sometimes copper wires would be wrapped spirally between the gauze or sheet metal and the inner pipe to give the necessary clearance. Sometimes the inner pipe would be of cast metal, with vertical or horizontal corrugations or ridges, which provided the clearance afforded in other cases by the wires.

Many different metals were employed in the attempt to minimize corrosion, but the life of strainers of this class was inevitably of short duration. Their openings were so fine that the gauze or sheet metal which held back the fine sand was necessarily very thin, and the openings themselves quickly became clogged by corrosion, the increase of which soon resulted in the destruction of the gauze or sheet.

The earliest noteworthy advance in strainer construction should be credited to Mr. A. D. Cook, whose strainer, first patented about twenty-five years ago, soon came into very general use. This strainer, shown in Fig. 1, is made of a seamless brass tube, a little smaller than the casing which it is to enter, and has horizontal slots which are cut from the inside of the tube. The slot openings will admit more water from a given sand stratum without letting in, or being clogged by, particles of sand, than will round or square holes of diameter equal to the width of the slot. The slots, being cut from the inside of the tube, are made wider at the inside than at the outside, so that grains of sand fine enough to enter the slot may not stick there, but be free to pass on through.

As, however, the No. 20 Cook strainer, which is, or was until recently, the coarsest Cook strainer listed, has slots of only about one-fiftieth of an inch in width, the Cook strainer, as found in the market, may be classed among the fine strainers.

Within the last year or so another strainer which merits especial mention has appeared on the market. This ingenious strainer, shown in Fig. 2, is the invention of Mr. E. E. Johnson, and consists of a strip of brass of special section so designed that when wrapped spirally around a core the successive convolutions overlap and clinch together, forming a cylindrical strainer of any desired length and diameter.

The strainer thus built up has a continuous spiral slot or opening running around its exterior from top to bottom, through which the water is admitted to a continuous passage between outer and inner walls, finally finding its way into the interior of the strainer through circular holes punched in the inner wall.

In the Johnson strainer, as built for the market, the diameter of the holes in the inner wall is in all cases 3-32-in., while the width of the outer slot is from 0.004 to 0.020-in. Strainers are listed for all pipe diameters from 2 to 12 ins.; but the makers are prepared to build to order strainers of much larger diameters.

For the same width of slot and length and diameter of strainer, the Johnson strainer has greater length of slot than the Cook. As is the case with the latter, the openings in the Johnson strainer are made larger on the inside than on the outside, to prevent their becoming choked by sand.

The width of the largest openings in the Johnson strainer, as it is at present listed, is, however, only one-fiftieth of an inch, which is about the same as that of the slots in the coarsest Cook strainer, so that this strainer as now made also belongs in the class of fine strainers.

It is evident that the finer the opening in a strainer the more likely it is to be clogged by particles of sand; and it is equally evident that where the diameter or width of the strainer openings is only a very small fraction of an inch, a very thin scale of verdigris or rust on the edges of the hole or slot will suffice to close the opening. It is also true that the metal of which the fine strainers have been heretofore made is so thin as to quickly fail from corrosion.

The Cook and the Johnson strainers are less open to this last objection than most of their predecessors. There would seem to be no reason, except that of slightly increased cost, why all of these strainers should not be made with slots so wide and metal so thick as to put them in the class of coarse strainers, thus greatly increasing their efficiency and durability.

The best modern practice now inclines to the use of the coarse strainer. The one objection that can be urged against the use of such strainers is that they do not hold back the fine sand, but this objection can in almost every case be readily overcome by intelligent treatment of the well before it is put into service.

The *crux* of the whole matter is the linear velocity of the inflowing water. If this velocity be great, and the openings in the strainer be large, fine sand will be drawn in as long as there is any left within the reach of the swiftly flowing water. If the velocity of the water be so low that it will not move the finest sand within its reach, then no more sand will come in.

By far the large majority of water-bearing strata contain at least a little gravel, and even where there is none, it can usually be introduced, by proper manipulation, through the well itself. In all such cases the coarse strainer is to be preferred. Before the well is put into service every effort should be made to pull in all the fine sand possible. This can best be done by persistently pumping the well at a rate much greater than its anticipated yield in actual service.

The air lift, while very uneconomical for permanent use, is well adapted to blowing out driven wells with coarse strainers, as the air pipe may often be placed far below the ultimate reach of the suction of the permanent pumps, and the well may be forced to its maximum capacity; while at the same time the agitation caused by the escaping air will thoroughly shake up the sand and gravel surrounding the strainer, thus giving the rapidly inflowing water a good chance to pull in all the particles fine enough to pass through the strainer openings. Such of these particles as may not be blown out of the top of the casing by the air lift should then be removed by the sand bucket, and the air lift again used to drag in more, these operations being repeated alternately until the mass of coarse particles held back by the strainer is so large that the linear velocity of the water passing through it will pull in no more sand. This done, the well will be ready for service. The strainer can never clog, and its useful life is limited only by the time required for the complete destruction by corrosion of the heavy metal of the strainer.

Fig. 2. Johnson Well Strainer.

Fig. 3 shows a type of strainer which the writer has used in a number of instances with very good results, the wells having been first treated as just described.

This strainer can be made of ordinary wrought-iron pipe, of any desired length and of a size just small enough to enable it to pass freely down the well casing. The openings may be either round or slotted, the latter being preferred, while the former are somewhat easier to have made in the average small machine shop. The usual form of lead packer is cast on to the top of the strainer and the lower end is closed by a cast-iron plug, screwed in, having a bail made of a curved iron rod, bolted through the cast iron.

No discussion of strainers for driven wells would

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†Two ingenious designs for open well strainers, devised and executed by Mr. Maury, were described and illustrated in a paper which may be found in Proc. Am. W. W. Assoc., for 1904; also see Eng. News, Aug. 18, 1904.—Ed.

be complete without some reference to the California, or "stove-pipe," method of well construction. A fuller description of this method, from which the following is condensed, may be found in Water Supply and Irrigation Paper No. 140, by Prof. Charles S. Slichter, published by the U. S. Geological Survey.*

The well casing consists of, first, a riveted sheet-steel "starter," 15 to 25 ft. long, made of two or three thicknesses of No. 10 sheet steel, with a

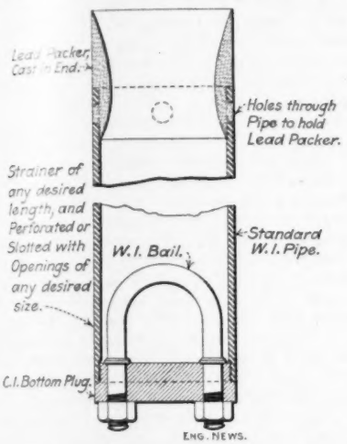

Lead Packer, Cast in End.
Holes through Pipe to hold Lead Packer.
Strainer of any desired length, and Perforated or Slotted with Openings of any desired size.
W. I. Bail.
Standard W. I. Pipe.
C.I. Bottom Plug.
ENG. NEWS.

Fig. 3. Maury Well Strainer

forged-steel shoe at the lower end. In ground where large boulders are encountered the starters are made heavier, the shoe is 1 in. thick and 12 ins. long, and three-ply instead of two-ply No. 10 sheet-steel body is used.

Above the starter the rest of the well casing consists of two thicknesses of No. 12 sheet steel made into riveted lengths, each 2 ft. long. One set of sections is made just enough smaller than the other, so that one length will telescope snugly inside of the other. Each outside section overlaps the inside section 1 ft., so that a smooth surface results both outside and inside of the well when the casing is in place, and so that the break in the joints is always opposite the middle of a 2-ft. length. It is these short, overlapping sections which are popularly known as "stove-piping." The sheets of steel can be taken to the field flat and the riveting done during the process of well construction.

In ordinary material the sand bucket is relied upon to loosen and remove the material from the inside of the casing. The casing itself is forced down, length to length, by two or more hydraulic jacks, buried in the ground and anchored to two timbers 14 ins. square and 16 ft. long, planked over and buried in 9 or 10 ft. of soil. These jacks press upon the upper sections of the stove-piping, the pistons of the hydraulic jacks being attached to the top of the casing by means of clevises which are hooked over the ears of the well cap.

The sand pumps used are unusually large and heavy. For 12-in. work they will vary in length from 12 to 16 ft., be 10⅝ ins. in diameter, and will weigh, with the lower half of jars, from 1,100 to 1,400 lbs.

After the well has been forced to the required depth a cutting knife is lowered into the well and vertical slits are cut in the casing where desired. A record of material encountered in digging the well is kept, and the perforations are made opposite such water-bearing strata as may be most advantageously drawn upon. A well 500 ft. deep may possess 400 ft. or more of screen, if circumstances justify it.

One type of perforator used for slitting the stove-pipe casing is handled with a 3-in. standard pipe, with ¾-in. standard pipe on the inside. In going down or in coming out of the well the weight of ¾-in. line holds point of knife up. When ready to "stick" the ¾-in. line is raised. By raising slowly on the 3-in. line with hydraulic jacks cuts are made ⅝ to ¾-in. wide and 6 to 12 ins. long, according to the material at that particular depth.

Another perforator has a revolving cutter which punches five holes at each revolution of the wheel. This style of perforator is called a "rolling knife."

A great many different kinds of perforators are in use in California; in fact, the perforator is a favorite hobby of local inventors. The different patterns in use seem to work well.

As the drift deposits in California are often of great depth, some of the strainers are made of unusual length. In coarse strata carrying much water the yield of wells with such strainers is sometimes enormous.

The stove-pipe casing has the advantages of cheapness, portability, ease with which it can be put together in the field, smoothness, absence of screwed joints, and adaptability to sinking with hydraulic jacks. The principal objection to it would appear to be the thinness of the metal of which the casing is built.

The method of cutting the strainers from the inside gives slots which increase in width from the outside to inside, and which are thus not likely to become clogged up.

The casing and the methods and appliances employed for sinking it and for cutting the strainer slots mark an important advance in the art of well construction.

The choice of strainer and of the method of treating it after it is in place can only be intelligently made after a thorough survey of the conditions, and more particularly of the nature of the water-bearing stratum. The best means of exploring this stratum is by full-sized test wells sunk with the sand bucket. It is impossible to secure accurate samples with the jet. After a sufficient number of test wells have been sunk the sand and gravel should be carefully screened through standard sieves of different mesh and the proportion of the whole which passes each sieve should be noted.

With these data at his command the engineer may then determine with some degree of confidence the proper width of opening for his strainer; while the log of the test well will show him how long the strainer should be and where it should be set. After setting the strainer it is sometimes necessary to blow out several cubic yards of the finer particles of sand and gravel from a single strainer before it is ready for service; but the cases are very few in which the results obtained in increased yield, diminished suction lift, durability of strainer and freedom from annoyance in the future will not repay many times their cost.

*See also Engineering News, Nov. 12, 1903.

THE SPRINGFIELD COAL MINE OF THE PEABODY COAL CO., AND THE METHOD OF SURVEY.*

By M. F. Peltier.†

The plant of the Peabody Mining Co. is one of the most modern coal mining plants in Illinois, and is situated near Springfield, on the Chicago & Alton R. R. The General Superintendent of the company is Mr. T. J. Armstrong.

This mine is designed to handle 2,500 tons of coal in eight hours, and at the present time is getting out about 1,200 tons of coal in that time. This plant has many advantages over other mines in the size of the compartments of the shaft, which allows the use of a 3-ton mine car. The self-dumping cages are economical from the fact that they do not need any attention at the top except one man or boy to pull off miners' checks. The steel tower is fireproof, and is equipped with shaker screens and chutes which handle and screen the coal with a small percentage of breakage.

The company owns about 2,000 acres of coal land and is mining what is known geologically as No. 5 seam, which is 6 ft. thick, having a strong slate covering and fire-clay bottom. Sinking was commenced Sept. 6, 1903, with J. C. Patterson in charge, and coal was reached 60 days later at a depth of 204 ft., which is a remarkable record for the speed at which the shaft was sunk and timbered. The main shaft is 10 × 20 ft. in the clear, and is divided into three compartments, two of which are 7 × 10 ft., used for hoisting purposes, and the other 3½ × 10 ft., used for electric wires, steam and water pipes. The shaft is timbered with white pine 6 × 10 ins., laid flat and has buntings 10 × 10 ins. between the compartments, making a very substantial piece of work. The escape and air shaft is 10 × 15 ft. in the clear, and is divided into an air chamber 10 × 10 ft., and an escapement 4½ × 10 ft.; it is timbered the same as the main shaft.

*Abstract of a paper read at the annual meeting of the Illinois Society of Engineers and Surveyors at Rockford, Ill., Jan. 17 to 19, 1906.

†Mining Engineer, Peabody Coal Co., Marion, Ill.

TIPPLE.—No portion of the equipment of a modern coal mine is of more importance than the tipple, for no matter what the capacity of the works are, or the amount of coal that is mined, unless the product can be placed on railway cars in proper condition for market, all other improvements are of no avail. In other words to a very large extent, the success of the plant depends upon the tipple. The head frame and tipple at this mine are built of structural steel, covered with corrugated iron, set on concrete piers and anchored with 1¼-in. bolts 5 ft. long. The tipple part is 20 × 64 ft., spanning the four loading tracks. The head frame is 68 ft. high from top of shaft coping to center of sheave wheels, and is braced with steel incline frame work extending from the steel girders carrying the sheave wheels to a concrete foundation at the foot of the engine house.

CAGES.—The coal is hoisted from the bottom of mine by self-dumping cages, built by the Duncan Machine & Foundry Works, Alton, Ill. The self-dumping cage is different from the cage commonly used in the northern coal fields, where the cars are pushed off and on the cage by hand, or with a steam pusher. With this cage the car rests on a platform which is supported by two legs, the lower ends of which are fastened to the arms of the rockers supported by a shaft. These legs are secured to a platform in such a way that the greater part of the weight of the platform is at the rear side. The shaft has bearing rollers which engage a suitable stop when the cage reaches the top of the shaft. This causes the forward end of the platform to tilt downward so the car can be dumped. The car is kept in place on the cage by yokes that encircle the wheels, and is counterbalanced by weights below the platform of the cage. The cages dump the coal into a weigh-pan built of ¼-in. sheet steel, and hung by rods on a Fairbanks-Morse set of hopper scales. After it is weighed the counterbalanced door of the pan opens and the coal falls by gravity on to the shaker screens.

SHAKER SCREENS.—The tipple is equipped with two sets of Duncan shaker screens and chutes which span the four loading tracks for screening and loading the coal into railway cars. These screens are 37½ ft. long by 6 ft. wide, built up of angles and plates. The plates are perforated with 1½-in., 2½-in. and 6-in. holes. The size of coal furnished is slack nut, egg, lump and run of mine. The screens are provided with cross heads which are connected to a 6-in. shaft by eccentric rods.

BOX CAR LOADER.—In order to load box cars with coal economically and with the least amount of breakage, the Smith box car loader* was installed by the Duncan company. This is in reality a device for handling cars while they are being loaded. The car rests on the platform of a cradle which is tilted by means of cables from two hydraulic cylinders 15 ins. diameter, and 24 ft. long, working under a pressure of 250 lbs. The cylinders move and the piston rods are stationary. The car is tilted at an angle of about 35°, and when the end that is down is loaded, the car is tilted back and the other end is loaded.

FAN.—This mine is one of the best ventilated mines in the state, and has a reversible double-inlet exhaust Capell fan, 13½ × 7 ft., built by William Clifford, Jeannette, Pa. The fan has a guaranteed capacity of 250,000 cu. ft. of air per minute against a 5-in. water gage, and on its trial it produced 400,000 cu. ft. of air without mine resistance with 4-in. water gage. It is driven by a direct-connected Chandler & Taylor engine, 18 × 18 ins. By an arrangement of doors, the fan can be changed in a minute to force the air down the mine.

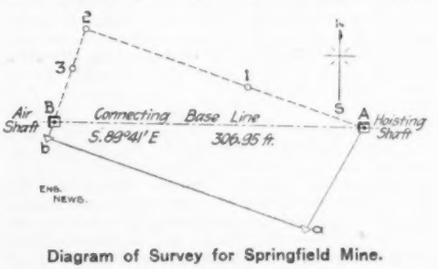


Diagram of Survey for Springfield Mine.

TRACKS.—There are four loading tracks underneath the tipple, also a storage track for empties having a capacity of 80 cars, and a storage track for loads having a capacity of 74 cars. These tracks were built and are owned and operated by the company. They are laid with 80-lb. steel rails, and have the necessary cross-overs, both above and below the tipple, to properly distribute the cars to the various tracks by gravity.

POWER PLANT.—The buildings are unusually substantial for mine buildings, the foundations being of concrete and the walls of brick. The boiler house is 75 × 50 ft., with an 18-in. wall and gravel roof supported by two steel trusses. The floor is paved with brick. There are at present four tubular Erie City boilers of 150 HP. each, with room for two additional boilers. Fuel is supplied by a coal drag which carries the slack from the shaker

*Engineering News, Aug. 3, 1905.

screen under the tipple, and distributes it under the boilers. The steel chimney is 100 ft. high and 6 ft. diameter.

The engine house is 40 × 50 ft., with 18-in. wall, and a gravel roof supported by one steel truss. The floor is concrete. There is one pair of first-motion hoisting engines (24 × 36 ins.), built by the Aetna Foundry & Machine Co., Springfield, Ill.; the differential conical drum tapers from 5 ft. to 7 ft. diameter, with an 8-in. steel

Fig. 1. 6-Ft. Concrete Pipe Sewer in Land Reclamation Project at St. Joseph, Mo.
S. W. Fox, Chief Engineer, Union Terminal Ry.

shaft, and is grooved for 1¼-in. steel rope. There is one Western Electric 110-volt generator, connected directly to a 50-HP. Ideal engine; this furnishes lights for all the buildings on top and for the bottom of the mine. The water supply for the entire plant is furnished by six 2-in. drive wells, put down by D. B. Medill, the Resident Superintendent, and driven 25 ft. into the sand and gravel of the Sangamon River bottom. The suction of a Cameron pump is directly connected to these wells, and the water is forced to a 30,000-gallon tank at an elevation of 70 ft.

UNDERGROUND WORKINGS.—The mine workings are laid off at right angles to the railway track which runs North 17° 22′ East, and are worked on the room and pillar plan. The double entry system is used, except in the main west entries which are triple. The mine is planned so that in the future all the coal can be caged on one side and the empty cars taken off on the other. The main side and stub entries are driven 10 ft. wide with a 30-ft. pillar between. Rooms are turned off the stub entries at right angles with 34-ft. centers and driven 250 ft. long, and 20 ft. wide, leaving a 14-ft. pillar between them. It is the custom in this mine to drive the rooms as well as the entries on sights, thus insuring the uniform thickness of pillar which also removes the danger of a squeeze or a creep. The main bottoms on each side of the mine are 16 ft. wide and 8 ft high, timbered with 12 × 12-in. yellow pine, and have double track laid with 35-lb. rails on a grade of 1½% in favor of loaded cars. From each side of the mine where the tracks lead to the cages, there is a cross-over diamond, or a double cross-over. By this arrangement the coal can be cross-caged from one track to the other, and the cars can be more easily regulated. The bottom is lighted by electricity. The main and side entries are laid with 35-lb. rails, stub entries with 25-lb., and rooms with 16-lb. rails. The overcasts which carry the air across from one entry to another are built of concrete for side walls, and the roof is made by laying steel rails about 18 ins. apart. These overcasts have an area of about 60 sq. ft. The mine is perfectly dry and free from gas.

ESTABLISHING THE MERIDIAN UNDERGROUND.—The general precision of a mine survey depends upon the instrument, tape, men and conditions of the survey. In surveying this mine by a previous survey, the common method of plumbing two lines down a single shaft did not prove altogether satisfactory, so the writer decided to try the rather unusual plan of one plumb line down the hoisting shaft, and another down the air shaft, and connecting the two points above and below ground. The base line on top was established, and down below the main west entry and air course were open which afforded a desirable connection. The direction of the base line underground A to 1 was assumed, and a traverse run from A to B (in the accompanying sketch) both above and below ground. The plumb lines are represented by the letters A and B, hanging in separate shafts, the surface stations being indicated by small letters, while the underground stations are numbered.

The surface survey and the traversing of this survey are as follows:

Surface Survey			Traverse of Survey.			
			Latitude.		Departure.	
Courses.	Bearings.	Distances.	N.	S.	E.	W.
A to a	S. 32° 22′ W.	113.88	.....	96.18	....	60.93
a to b	N. 72° 38′ W.	264.00	78.77	.....	....	251.96
b to B	N. 17° 22′ E.	20.00	19.08	.....	5.97	.....
			97.85	96.18	5.97	312.92
			96.18	.....	.....	5.97
		1.67	.....	.....	.....	306.95

The bearing of the closing course of the surface survey, or the line A B, is found as follows:

$$\frac{306.95}{1.67} = 183.80 \text{ Tan} = 89° 41'$$; the bearing of the line is therefore S. 89° 41′ E.

To find the length of this line:

$$\frac{306.95}{\text{Sine S. } 89° 41' \text{ E.}} = \frac{306.95}{0.99988} = 306.95.$$

Fig. 2. Handling a 3-Ft. Section of 72-In. Reinforced Concrete Sewer Pipe.
Jackson Cement Sewer Pipe Co., Jackson, Mich., Makers.

The underground survey and the traversing of this survey are as follows:

Underground Survey.			Traverse of Survey.			
	Assumed		Latitude.		Departure.	
Courses.	bearings.	Distances.	N.	S.	E.	W.
A to 1	West	125.53	....	.....	....	125.53
1 to 2	N. 88° 45′ W.	166.60	1.45	.....	....	166.56
2 to 3	S. 2° 15′ W.	42.00	....	41.96	....	1.64
3 to B	S. 0° 18′ E.	49.50	....	49.49	0.25	.....
			1.45	91.45	0.25	293.73
			....	1.45	....	0.25
			....	90.00	....	293.48

The bearing of the closing line of this survey, or the line A B is found as follows:

$$\frac{293.48}{90.00} = 3.26 \text{ Tan.} = 72° 57'.$$

The bearing of the line A B underground is therefore N. 72° 57′ E. To find the length of this line:

$$\frac{293.48}{\text{Sine N. } 72° 57' \text{ E.}} = 306.95.$$

The length of this line A B underground is therefore found to check with the same line on the surface, but the underground bearing is N. 72° 57′ E. and the surface line is S. 89° 41′ E., so the underground line must be swung 16° 44′ to the right. The corrected bearings of the underground survey are as follows:

Courses.	Bearings.	Distances.
A to 1	N. 73° 16′ W.	125.53
1 to 2	N. 72° 1′ W.	166.60
2 to 3	S. 18° 59′ W.	42.00
3 to B	S. 18° 2′ W.	49.50

SEWERS OF REINFORCED CONCRETE PIPE IN RECLAIMED LAND AT ST. JOSEPH, MO.

In connection with the work of the Union Terminal Ry. Co. at St. Joseph, Mo., there have been constructed some large sewers of concrete pipe which are of particular interest. The work referred to is part of a project for the reclamation of land from the Missouri River, and the first step was to form accretions of deposit upon the area to be reclaimed by means of a system of permeable pile dikes. About 1¼ miles of these dikes were built between March and October, 1905, with the result that through their functions as silt catchers a deposit aggregating nearly 1,000,000 cu. yds. has been made by the river.

This reclamation work involves the extension of the municipal sewers to the harbor line. There are six of these sewers, four of which are being extended with reinforced concrete pipes, as follows: 36-in. Felix St. sewer, extended 376 ft.; 42-in. Patee St. sewer, extended 217 ft.; 48-in. Messanie St. sewer, extended 371 ft.; 72-in. Olive St. sewer, extended 173 ft. The pipes were manufactured on the ground, and were laid on the pile cross dikes, which were located on the lines of the sewer extensions so as to serve the double purpose of silt catchers and supports for the sewers. Fig. 1 is from a photograph taken Jan. 24, 1906, and shows the Olive St. (72-in.) sewer extension and cross dike, leading to the dike along the river front of the area to be reclaimed. The floor system for the support of the pipe consists of beams 18 ins. c. to c., resting on bolting pieces bolted to the piles. As the pipes are made in 36-in. lengths, each pipe is thus supported at two points.

The concrete for the pipes is composed of 1 part American Portland cement, 2 parts Missouri River sand and 3 parts crushed limestone, the latter ranges from the size of a pea to that which would pass a 1½-in. ring. No waterproofing has been applied and no finishing coat was applied to the interior of the pipe, the process of manufacture being such that this latter was not deemed necessary. One end of each pipe is of reduced thickness, forming an outside groove when the pipes are laid. This may be seen by the view of a 72-in. pipe in Fig. 2. Each pipe is reinforced by flat steel hoops and by longitudinal flat steel bars, the ends of the latter projecting through the concrete and being hooked. In laying the pipe, these hooks of adjacent pipes overlap (side by side), and a metal hoop is put around each joint, engaging the hooks of the two pipes. Wedges are then forced into the hooks to tighten the joint and concrete is packed into the groove formed by the pipes, covering the metal and making the sewer of uniform thickness throughout.

The next process in the reclamation project will be to complete the filling by pumping sand from the bed of the river outside the dikes, the level of the newly made land being thus raised to that of the old main bank of the river, which is some 8 ft. above the extreme flood height. In this way the sewers will be embedded in sand and not subjected to such severe stresses as would be imposed if the filling were done with dry material.

The work was planned by Mr. S. W. Fox, Chief Engineer of the Union Terminal Ry. Co., of St. Joseph, Mo., to whom we are indebted for information concerning it. A contract for the pipe was awarded to the Jackson Cement Sewer Pipe Co., of Jackson, Mich.; the company made the pipe on the site and laid it in place, except that on the Felix St. sewer the pipe laying was done by hired labor. The company makes this pipe in diameters of 6 ins. to 6 ft.

TREE PLANTING is under consideration by the Canadian Pacific Railway along its prairie lines, in order to provide material for ties and fence posts.

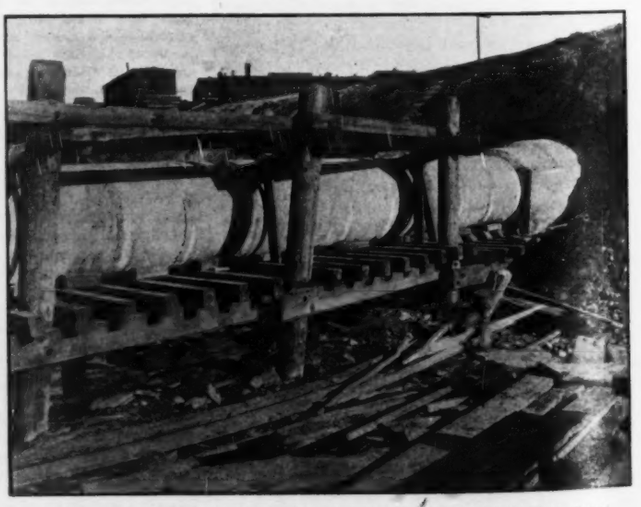


FIG. 3. CONNECTION OF CONCRETE PIPE SEWER WITH CITY SEWER ON MESSANIE ST.

TESTIMONY OF WILLIAM NELSON CROMWELL BEFORE THE SENATE COMMITTEE ON INTEROCEANIC CANALS.

In printing in our last issue an abstract of Mr. John F. Wallace's testimony before the above committee certain statements were included reflecting in some degree on Mr. Wm. N. Cromwell. It is a matter of fairness, therefore, we print below some extracts from Mr. Cromwell's testimony given on Feb. 26 and 27.

Mr. Cromwell stated that his law firm, Sullivan & Cromwell, of New York City, has been the General Counsel of the Panama R. R. Co. for over twelve years and of the New Panama Canal Co. for nine years. In the summer of 1904 he was appointed General Counsel to the Republic of Panama. Neither he nor his firm have been the attorneys for the Isthmian Canal Commission or for the Government, but on several occasions the President and the Secretary of War have sought information and advice on particular topics. At the Government's request he arranged for the purchase of the outstanding minority stock in the Panama R. R., and did the work without compensation.

Regarding the interview between Secretary Taft and Mr. Wallace at the Manhattan Hotel on June 25, Mr. Cromwell stated that he was present at Secretary Taft's request, the Secretary desiring his advice and counsel in connection with the Chief Engineership and also in connection with arrangements with the Pacific Mail Steamship Co., an interview with Mr. Schwerin, Vice-President of that company, following immediately after the Wallace interview.

With reference to Mr. Wallace's statement to the committee that he felt that his position as Chief Engineer was becoming untenable on account of Cromwell's influence in various matters, Mr. Cromwell presented a letter written by Mr. Wallace to him (Cromwell) on May 26, 1905, two days after his arrival on the Isthmus, and reading as follows:

My Dear Mr. Cromwell: During my restful voyage to the isthmus on the "Seguranca," while mulling over the various matters connected with our work, my mind repeatedly turned to the words of advice and counsel which I received from you, particularly the conversation which we had at your house, where Mrs. Cromwell and yourself so kindly entertained us the night before our departure.

The more thought I give the matter the more I am impressed with your words of wisdom, and it is needless for me to say that I will endeavor to carry out the policy outlined.

In looking back over the events of the past few months I become more and more impressed with the wisdom underlying the action of the President and the Secretary of War, as well as with the wisdom of their "privy counsel," and the tactful manner in which matters have been guided through the troubled waters of the sea of complication which has surrounded the situation.

While my own manners and methods are, as you know, blunt and direct, my deficiencies in this direction only serve to enhance the appreciation I have of the skilled and polished diplomat who has made this great work a possibility, and whose thoughtful care and guiding hand will be the most important factors in the ultimate success of the enterprise.

In closing, permit me, my dear Mr. Cromwell, "to lift my hat to you."

Sincerely, yours, John F. Wallace.

Mr. Cromwell then continued as follows:

It is manifest, therefore, that when he wrote this letter to me, two days after his arrival on the Isthmus, he had had "six days' uninterrupted thought," which he was "able to give the subject in all of its bearings," and which letter is totally inconsistent with the explanation he has given to you.

It therefore conclusively appears that he at no time contemporaneous with the event alluded or referred to me as being in any sense whatever the cause for his resignation, and the fact is that I was not in any manner responsible for his resignation.

In conclusion, permit me to state that the only financial interest that either I or any member of my firm or any associate has upon the Isthmus or in the Republic of Panama is a personal investment of mine in the capital stock of the Panama-American Corporation. I subscribed and paid for, at par, $51,800 in the capital stock of this company, out of a total capital of $229,000. This company is engaged in supplying to the inhabitants of the city of Panama electric light, ice, and telephone service; and it is also a minority stockholder in a small ice company in Colon. It is a local and private affair, and my investment was in large part induced by a desire to assist a local enterprise.

I may add that we have not had any dividends.

Mr. Cromwell testified that he called to see Wallace at his hotel on his arrival in New York, having been delegated by Secretary Taft to arrange for an interview on Sunday, during the Secretary's brief stay in the city. We quote verbatim as follows:

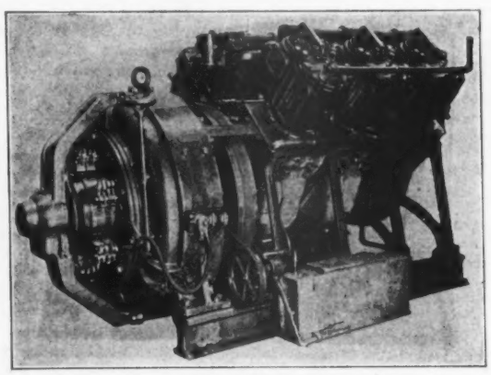
MR. CROMWELL.—I have had a very kind and friendly feeling for Mr. Wallace and I was aware, though he did not know it, that he had determined to accept this other place. I tried to check Mr. Wallace's determination by saying to him in the friendliest way: "Now, my dear Wallace, the air is full of rumors and stories. I hope you will do nothing rash." He replied: "Well, I will state it to the Secretary, as I have concluded to do."

SENATOR KNOX.—At the Manhattan Hotel interview did Mr. Wallace at any time make any objection to your presence?

MR. CROMWELL.—He did not, sir. And I hope that there will be nothing in my statement that will be indicative of any unkind feeling, for there has been nothing but the warmest and most cordial relations between Mr. Wallace and myself. At the interview, when the Secretary requested me earnestly to stay, not only did Mr. Wallace make no objection, either in word or in manner, but he began to address us both in a plain and natural manner; and he, moreover, at the conclusion of that most painful incident, came around the table, and with his eyes dimmed—as I confess were mine, as well—grasped my hand, and we shook hands good-by. And I said, with absolute sincerity, "I am deeply moved and sorry over this."

SENATOR MORGAN.—Why was it painful?

MR. CROMWELL.—It was painful to have relations severed with a gentleman with whom we had been working, with whom we had most pleasant associations, who had grasped the hand of each of us only a few days before, expressed the deepest satisfaction and gratitude for the honors which had been given to him, who had dined at my home the night before his departure as my guest, and whom I had seen at the steamer the next day and bade good-by, to have him write me the letter of May 26 to which I have referred, and then have him turn up within two or three weeks afterwards, throwing up this job and leaving the Secretary and the President, on the eve of the Secretary's departure for the Philippines for three long months, in this perplexity and uncertainty, with the fever season coming on, with the work uncertain, and with no man of power or position in command.



Engine and Generator for the Strang Gasoline-Electric Railway Car Co.

GASOLINE-ELECTRIC MOTOR CARS FOR AN INTERURBAN RAILWAY.

The use of independent motor cars has usually been considered in connection with ordinary steam railway service, but several gasoline-electric motor cars are now being built to operate an interurban railway near Kansas City. There are probably many such lines where a sufficient service can be given by this system, avoiding the expense of power station and overhead equipment. The car resembles the ordinary interurban electric car in appearance, and is mounted on a pair of four-wheel trucks. It is 52 ft. 9 ins. long over the body (including the rear vestibuled platform), and is divided into three compartments—engine room, 14 ft. 8 ins.; smoking compartment (12 passengers), 10 ft. 8 ins.; main passenger compartment (30 passengers), 27 ft. 5 ins. The weight of the car is 39 tons.

The principal feature, of course, is the power equipment. A six-cylinder gasoline engine, directly coupled to a 50-KW. 250-volt direct-current generator, is placed with its shaft in the center line of the car. In ordinary service the current is delivered directly to the two 50-HP. motors on the front truck, but when the car is slowing down, drifting or at rest, the surplus current is delivered to a 112-cell storage battery of 200 ampere-hours capacity. The battery furnishes the extra power required in starting and accelerating, and in ascending heavy grades. The operation is entirely automatic and is under the control of special governors. The speed of the car is regulated by a series-parallel controller. The engine, shown in the cut, is of special design, having inclined cylinders arranged in the form of a V, with three cylinders on each side; this is to secure a short crank shaft and to reduce vibration. The engine is of the four-cycle type, with jump-spark ignition, and its cylinders are 8 × 10 ins. Oil is pumped continuously to the bearings, and a centrifugal pump circulates the water for the cylinder jackets; the water from the jackets may be used to warm the car in winter. The gasoline tank (100 gallons) and the storage battery are placed beneath the car. The consumption of gasoline is said to average 0.45 gallons per car mile.

The first car built on this system made the run from Philadelphia to New York on Feb. 26 at an average speed of 48 miles per hour. It started from New York for San Francisco on Feb. 28, running via the West Shore, Lake Shore, Alton, Rock Island and Southern Pacific railways.

This motor car system is owned by the Strang Electric Railway Car Co., 15 Wall St., New York, and the engine was designed by Mr. Lars G. Nilson, Chief Engineer of the company. The interurban cars above described are being built by the J. G. Brill Co., of Philadelphia, Pa., to operate the Missouri & Kansas Interurban Ry. between Kansas City, Mo., and Olathe, Kan., 20 miles, serving four intermediate towns. It is expected that the road will be in operation by June, and that four motor cars will be used, hauling trail cars and making about 36 trips per day. The line is built on a private right-of-way, except through towns and at terminals, and is laid with 70-lb. rails and 2,640 white oak ties to the mile. The maximum grade is 1¼%, and the sharpest curve is 8°. The road is bonded for $25,000 per mile, and was built by the Metropolitan Finance Construction Co., of which Mr. W. B. Strang is President.

THE SANITARY CONDITIONS IN THE NEW YORK SUBWAY.

A report on the temperature and other sanitary conditions in the New York Subway was made by Geo. A. Soper, Assoc. M. Am. Soc. C. E., on Feb. 1. A preliminary report by Mr. Soper was printed in our issue of Nov. 9.

The present report states that the air of the subway is changed so rapidly by natural ventilation, the movement of trains, etc., that the centrifugal blowers which have been put in are of comparatively little importance in their influence on the air. We quote the following:

The removal of about 280 sq. ft. of vault lights at 96th St. gave immediate and sensible relief in the hot summer weather, but the opening of 90 effective sq. ft. in the roof of the stations at 14th St., of 180 effective sq. ft. at the Grand Central Station and 170 effective sq. ft. at the Brooklyn Bridge Station was not enough to make their consequences felt.

With respect to the location of blow holes, it appeared possible to determine with scientific exactness the conditions under which they may be most effective. Blow holes have been proved in this investigation to have much value in aiding ventilation. In fact, special studies of the condition of the air above and below 50th St. showed plainly that the air was much purer in the sections which have blow holes than in those which do not have them.

Currents of air due to the combined action of the wind in the streets and the motion of the trains were measured at several stairways. As a result of 80 observations at eight stations the air was found to have moved in and out of the subway at an average rate of 573,000 cu. ft. per hour at a single stairway.

A local train was observed to push out about 15,000 cu. ft. and an express train about 45,000 cu. ft. of air through the passageways of a local station. This air

was replaced after the trains passed by corresponding indraughts from the streets. The same air did not move in and out of the subway, but fresh air replaced the subway air. The maximum velocity of air moving in at any stairway was 16½ miles per hour. On this occasion the air was passing through this stairway at the rate of 3,800,000 cu. ft. per hour.

The use of centrifugal fans, as experimented with under the direction of your Chief Engineer near the Brooklyn Bridge, 14th St. and Bleecker St. Stations, and the use of automatic louvres between 59th and 66th St., did not produce results which were visible, although about 800 analyses of carbon dioxide were made to observe them.

Observations of the passage of air from one station to another showed that the air of the subway, outside of the trains, may, in some cases, move from one station to the next at the rate of 640 lin. ft. per minute. The air between stations never became badly vitiated, according to my analyses.

TEMPERATURES SINCE JULY 1, 1905.—Throughout my investigation the air of the subway has been warmer than the air of the streets. This difference has increased considerably during the autumn and winter months. In the early part of July the difference between the average temperature for the day, inside and outside the subway, was less than 5°. In the latter part of September it was over 10°. In January it was at some stations about 20° warmer than the outside air; an average difference for a week of 30° was found at one station.

The subway air grew warmer as the summer season advanced. It averaged 81.0° through July. In the week of August 4 to 10 it was 83.4°. Thereafter it declined very gradually until the latter part of September, when it was 76.0°. In the week of September 29 to October 5 there was a slight rise to 78°. This was followed by a more rapid decline than had occurred at any time before and excessively high temperatures were not again experienced.

The highest temperature observed by me in the subway was 95°. This occurred at the Brooklyn Bridge Station July 18, 1905. The hottest week was that of August 4 to 10, inclusive. The average daily temperature for the subway during this time was 83.4°; for the outside air 78.2°; difference 5.2°. The maximum temperature observed in the subway during this hottest week was 88.2°; in the streets it was 88.2° at the same time.

HUMIDITY.—The relative humidity in the subway has generally been less than out of doors, but the dew point has been higher. In other words, the amount of moisture present has been actually greater, but it has appeared less in the subway than out of doors. There have been no fogs nor mists in the subway. A faint haze has not been uncommon.

The average relative humidity of the subway for July and August was 57.5%; for the outside air 60.6%; difference 3.1%. The greatest average relative humidity occurred during the week when the average temperature was highest. During this period the relative humidity averaged 64.4%.

Dr. Soper condemns the broken stone ballast, particularly at stations, on account of the filth which it collects and retains. The air of the subway shows only a trifling excess of carbon dioxide over the air in the streets. Odors and dirt in the subway appear to be due to carelessness on the part of attendants in charge of toilet rooms, etc.

THE RELATIONS BETWEEN MUNICIPALITIES AND STREET RAILWAYS.

The numerous cases of active antagonism between municipal authorities and street railway companies, which indicate a widespread movement for the readjustment of franchise relations on a basis more equitable to the public, have led us to make some inquiry as to the conditions existing in various cities, and we present herewith a compilation of the replies to specific questions as to present conditions. These cities are of various classes and in various parts of the country, and the franchise terms show little relation or uniformity. It is to be noted, however, that in some cases the present franchises are of comparatively recent date, taking the place of earlier franchises, which gave even less return to the city for rights so carelessly granted. In our issue of Nov. 30 we published an article upon the terms of street railway franchises in several cities, showing a range of from 20 years to perpetuity, while in two cases (Boston and Washington) there is no specified limit, but the franchises can be revoked by the authorities. That article, which to some extent supplements the more extensive information given below, was compiled from a report made to the U. S. Senate by the Commissioners of the District of Columbia, under date of Oct. 26, 1905. The report was prepared in conformity with a resolution directing the Commissioners to investigate and report upon the conditions and restrictions under which such franchises are granted in cities having a population of over 200,000; also the character of the trackage arrangements, and the extent to which street railways are placed under State or municipal control. Some further notes from the report are included in the present article, and the general subject of the relations between municipalities and street railway companies is discussed in another column.

BALTIMORE, MD.—There is but one company, the United Railway & Electric Co., and it is required to make financial reports to the city. The periods and dates of expiration of franchises vary on different parts of the system. The city has 430.7 miles of streets, of which 383 miles are paved, and on these the company has 13.8 miles of single track and 107.2 miles of double track. The city has power to regulate the form of rail and gage of track; to require the company to pave between the rails and for 2 ft. outside, with the same material as used by the city on the rest of the street; and also to require it to remove snow from and to sprinkle the track. These powers are enforced, and the use of a 9-in. grooved girder rail is required. The street repairs are done partly by the city and partly by the company. There is trouble from electrolysis, and some experimental work has been done to find a remedy for this. The Senate report referred to above states that by the new charter the granting of a franchise requires not only favorable action by the city council, but also approval by the Board of Estimates, which board is directed by the law to inquire as to the money value of the franchises. This city is also exceptional in having from the first introduction of street railways (about 1860) insisted upon a large payment to the city for the privilege of using the streets; this was originally 20% of the gross receipts, subsequently reduced to 9% by State law. The City Engineer has general authority to "regulate" the work of the company, and the Electrical Commission also has certain powers in connection with the city electrical subways. Mr. B. T. Fendall is City Engineer.

BOSTON, MASS.—A State law governs the granting of street railway franchises, and provides for their revocation under certain conditions. It also limits the issue of capital stock to $10,000 per mile within cities and $2,500 per mile outside of cities; but after construction has been commenced this may be increased, subject to such conditions as may be prescribed by the Board of Railway Commissioners. As to the street work, the Senate report states as follows:

> The general State law provides that there shall be no requirements on street railway companies as to paving adjacent to their tracks, the percentage on the gross receipts being considered as taking the place of such requirements, but this law stated that it should not apply to such street railways as were at the time of its passage owned in part by or leased to the Boston Elevated Railway Co. As this company at the time leased all street railways in Boston, with the exception of about five miles of track, a previous law which required the companies to keep in repair the streets between rails and for a space of 18 ins. on each side of the outer rails applies to all street railways in the city, with the exception of this five miles. The method of constructing tracks is prescribed by the Board of Aldermen of the city, or the selectmen of a town. The State law requires that the tracks shall conform to changes in street grades.

The above wording is somewhat misleading in that it appears to make the paving of 18 ins. outside of the rails apply to paved streets. As a matter of fact, the law states that every company must keep in repair the paving of the portions of streets, roads and bridges occupied by its tracks, "and if such tracks occupy unpaved streets or roads, shall, in addition, so keep in repair 18 ins. on each side of the portion occupied by its tracks."

BUFFALO, N. Y.—The former four companies were merged three years ago into the International Railway Co. The franchises are all long-time grants; the last was given in [illegible] and runs for 66 years. The company is [illegible] to pay 2% of its gross receipts to the c[illegible]. There are 345.5 miles of streets (not incl[illegible] roads), and the company has 185.3 [illegible] of track. The city has, and enforces, p[illegible] as to track construction and street paving [illegible] and sprinkling. It requires the use [illegible] rails, and all repairing and new work [illegible] have stone block paving on concrete base. [illegible] also requires the company to do all paving, [illegible] ring, cleaning and sprinkling between and [illegible] 2 ft. outside of the rails. Where the city [illegible] or repaves a street in which tracks are [illegible] the company must repair and repave this same space to correspond with the new pavement and must keep this in good condition for five years. There is not much trouble from electrolysis, the remedy being to bond the mains. The city's authority over the company is exercised by the Commissioner of Public Works and his deputies, the Engineering Commissioner and the Street Commissioner. Mr. C. M. Morse is Deputy Engineer Commissioner.

CHICAGO, ILL.—The companies are required by their charters or by local ordinances to pave and maintain the paving for a width of 16 ft. in the center of the street where double tracks are laid, and 8 ft. for single tracks. The ordinances provide for the style of rail and require the tracks to conform to street grades.

CINCINNATI, O.—Under the recent 50-year franchise ordinance the Board of Administration provides (among other things) for the laying and relaying of tracks, the paving of streets, etc. The company is not required to pave any portion of the street except at certain important intersections of streets in the downtown portions of the city, and where the reconstruction of the tracks makes this necessary.

CLEVELAND, O.—All lines are owned by the Cleveland Electric Railway Co., which has 240 miles of single track, and its franchises expire between 1905 and 1914. It makes no financial returns to the city. It is required to use a 9-in. grooved girder rail, to pave between the outer rails and for 1 ft. outside of these rails, and also to sprinkle the tracks; it maintains the paving, but does no street cleaning. It is further required to make changes to conform to new street grades. There is some trouble from electrolysis, and the present remedy is to make better return circuits. The authority of the city over the company is exercised by the Board of Public Service. Mr. Wm. J. Carter is City Engineer.

COLUMBUS, O.—From Mr. Julian Griggs, City Engineer, we have the following complete information as to the street railway situation:

> The greater portion of the street car mileage in this city is owned and operated by one company, the Columbus Railway & Light Co. Seven tickets are sold for 25 cts., and when the gross earnings reach $1,750,000 per year, eight tickets must be sold for 25 cts. By present indications this rate will obtain in two years. There are five interurban companies owning tracks in the city, and the whole mileage so owned is operated for local service on a 10 or 15-minute schedule, with eight tickets for 25 cts.

The following table gives particulars as to miles of track. The franchises for all the six companies are for terms of 25 years, and all expire in 1925, except that of the Columbus Railway & Light Co., 1926:

Name of Street Railway company.	Right of way, miles.	Double track, miles.	Single track, miles.
Col., Ry. & Lgt. Co.	42.64	35.67	6.97
Col., London & Springfield Ry. Co.	6.71	2.41	4.30
Col., Buckeye Lake & Newark Trac. Co.	2.40	1.05	1.35
Cent. Market St. Ry. Co.	8.00	6.33	1.67
Col., Grove City & S. W. Ry. Co.	0.61	0.48	0.13
Col., Urbana & West Elec. Ry. Co.	1.01	0.93	0.08
Totals	61.37	46.87	14.50

> The Columbus, Delaware & Marion Railway and the Scioto Valley Traction Railway companies operate an hourly service into Columbus over the Central Market Street Railway tracks, and the Columbus, New Albany & Johnstown Railway Co. does the same over the tracks of the Columbus Railway & Light Co., but these three last-named interurban companies have not separate franchises.
>
> The Columbus, London & Springfield Railway Co.'s franchise ordinance provides for the payment to the

city of 2[illegible] gross receipts, and the auditor of the city has [illegible] to examine the books of the railway company [illegible] the purpose of determining such gross earnings. [illegible] believe that under the Ohio law a provision [illegible] payment on gross earnings has been declared [illegible], and on that account the same is not operative. [illegible] except as above I think there is no provision for exam[illegible]n of accounts.

The cit[illegible] has power over all of the railway companies having f[illegible]hises as to the method of track construction, and [illegible]ince the franchises above noted were granted all track[illegible] paved streets has been with 9-in. grooved girder rail on concrete foundation. Such construction, with ties about 2 ft. c. to c., has cost approximately $25,000 per mile of single track; with iron ties spaced 10 ft. apart, and concrete beams, the cost is $20,000 per mile of single track. On unimproved and macadam roadways the use of tee rails has been permitted, but the Columbus, London & Springfield Railway Co. is now claiming that the city has no power to change to grooved construction when these streets are improved. The other franchises are explicit on this point, so that there can be no contention, and are enforced.

The railway companies are required to pave and maintain the paving of all space between their rails and for 1 ft. outside, and no more. They are required to pay the cost of sprinkling and sweeping the portion of the street which they are required to pave and maintain, as above noted; the city to do the work and render bill for the cost. The franchises give the companies the right to do their own paving and track construction, but not infrequently they arrange with the contractor who paves the street to do the whole or a part of this work.

There has been as yet very little trouble from electrolysis, which I have thought due to excellence in the construction and management of our principal company. The franchises, however, all provide for a double-trolley system, or other approved construction, to remedy this trouble should it occur.

The franchises are not uniform in their specifications as to who shall control and decide as to details of construction and operation. In some cases the City Engineer has large powers, in others the Board of Public Service, and in some the City Council must make the order.

DETROIT, MICH.—To Mr. Robert H. McCormick, City Engineer, we are indebted for the following statement:

There was originally in Detroit one street railway company, known as the Citizens' Railway Co.; the fare was 5 cts., six tickets for 25 cts., and the company did all the paving in its tracks and for 18 ins. outside. In 1894 a rival company, known as the Detroit Railway, appeared in the field, secured a 30-year franchise and built a number of miles of track. It was known as the 3-ct. line, tickets being eight for 25 cts., but a 5-ct. cash fare was charged. The city was to do all paving and maintain the same. In 1899 these lines consolidated, under the name of the Detroit United Railway, the rates of fare and agreement for paving remaining the same as before.

We have in the city 700 miles of streets, and there are about 200 miles of street car tracks. The franchises of the old Citizens' company expire at different periods, ranging from 4 to 17 years, and that of the Detroit Railway in 1929. There is no tax on the earnings of the Detroit Railway, but the Citizens' company pays 2% on the gross earnings and makes a sworn statement of the same to the City Comtroller.

The railways are compelled to use a girder grooved rail, and the one now being used is a 9-in. girder rail, 90 lbs. per yd. Wooden ties 5 ins. thick are used, and 16 ins. of broken stone ballast, 8 ins. of which is below the ties.

The Citizens' company is compelled to clean its tracks, and both companies sprinkle when necessary. The Water Board complains of trouble from electrolysis, but I am not posted as to the extent of the injury to pipes. The Commissioner of Public Works is the only city officer having control over the relations with the company.

INDIANAPOLIS, IND.—The ordinance granted under the State law requires the company to pave the space occupied by the track and for 18 ins. outside; also to maintain and repave the same on order of the Board of Public Works.

JERSEY CITY, N. J.—There is only one company, and the franchise requires it to pave between the tracks and for 2 ft. outside, with the same kind of pavement as is used on the street; it must also maintain this part of the pavement.

MILWAUKEE, WIS.—The Milwaukee Electric Railway & Light Co. owns all the lines, and its franchise expires Dec. 31, 1934. There are 534 miles of streets and 115 miles of tracks. The ordinance passed in 1900 specifies the gage of tracks and requires the use of "modern improved rails as approved by the Board of Public Works"; the company is also required to furnish power for operating the city's drawbridges and to remove snow from the tracks. The city constructs the paving, and the company keeps in repair the strip between the rails and tracks and for 1 ft. outside each outer rail; the company may be required to sprinkle the streets, but this is not yet enforced. The requirements as to repair work are as follows:

It shall be the duty of the railway company at all times to keep in good repair the roadway between the rails and for 1 ft. on the outside of each rail, and the space between the two inside rails of its double tracks, with the same material as the city shall have last used to pave or repave these spaces and the street previous to such repairs; unless the railway company and the Board of Public Works shall agree upon some other material.

Whenever the city shall determine to pave or repave any street upon which street car tracks are or shall be situate, the Board of Public Works shall give notice to the railway company, and the company shall immediately make all such repairs, connections, conduits and improvements as it shall deem necessary. After any such street shall be paved by the city the pavement shall not be opened or disturbed by the company for any purpose, except by permission in writing, signed by the Mayor and the Board of Public Works.

The tracks are laid with 7-in., 95-lb. tee rails. When pavements on concrete are laid the company puts 6 ins. of concrete under the ties, and furnishes granite grooved blocks to go on inside of rail for flange space on asphalt and bitulithic pavement. This track construction was described in our issues of March 6, 1902, and Jan. 5, 1905. There is not so much trouble with electrolysis as in former years. The city's authority over the company is exercised by the Board of Public Works. Mr. Charles J. Poetsch is City Engineer.

NEW HAVEN, CONN.—There is only one street railway company, the Consolidated Railway Co.; its franchise is unlimited, and it makes financial reports to the State. There are 200 miles of streets, with 26.1 miles of double track and 12.4 miles of single track. Plans for track construction have to be approved by the Board of Aldermen, but the company has the right of appeal to the State Railroad Commissioners. The company is required by law to keep in repair and to sprinkle a width of 9 ft. of street for each line of track. For new pavements, the city does the work and collects an assessment; but this is in litigation. The Board of Aldermen cannot order any better pavement for the tracks than is laid or to be laid in the rest of the street. A tee-rail is now used, but it is hoped to secure a change. There is some trouble with electrolysis in the case of water pipes, but the water-works are owned by a private corporation, and the City Engineer is not familiar with the arrangements. The City Engineer determines the exact alinement, curves and grades; this being generally included in each order of the Board of Aldermen approving plans. The Director of Public Works is the head of the department and sees to the enforcement of the regulations as to maintaining and sprinkling the pavements. Mr. C. W. Kelly is City Engineer.

NEW ORLEANS, LA.—Under the State law, franchises are granted only to bidders offering the highest percentage of gross receipts. The company is, as a rule, required to maintain its right-of-way and a width of 1 to 2 ft. on each side of the track. It may also be required to change its tracks to conform to new street grades.

NEW YORK, N. Y.—The Senate report already referred to shows that the State law provides that street railways shall keep in permanent repair the portion of the streets between their tracks and rails and for a width of 2 ft. outside of the tracks, under the supervision of the local authorities. In case of neglect to do this the authorities are empowered to do the work at the expense of the railways.

PHILADELPHIA.—This city is exceptional in requiring the companies to pave the entire width of the streets, and the conditions obtaining in this city are described as follows in the Senate report:

When, about 1892, the street railway companies of Philadelphia desired to change from animal power to electric traction, the city seized the opportunity to require them to pave the entire street surface in the streets occupied, and to maintain the pavement in the future. The same provisions were inserted in the new franchises for surface lines granted in 1901. This requirement constitutes virtually a greater compensation to the city than the percentages on gross receipts required in most cities where the street railway company paves only the strip between its tracks. The Philadelphia railways have expended several millions of dollars in paving streets, and their annual expense for maintenance is quite large. Since 1893 they have repaved with improved pavement over 400 miles of streets. The companies are required to lay a rail approved by the Board of Surveyors and to make their tracks conform to grade.

PROVIDENCE, R. I.—The lines are all owned by the Rhode Island Co., whose franchise runs for 20 years. The company pays for laying and maintaining the pavement between the rails and 18 ins. outside; cleaning and sprinkling are paid for by the city. The city determines the location of tracks and style of rail. A grooved rail is used, with "almost every kind of track construction known"; the best construction is that with a concrete beam under each rail, concrete bed with paving, and filled joints. There is some trouble from electrolysis, largely due to poor bonding; the remedy is the use of thorough bonding and return copper conductor. The Commissioner of Public Works exercises control over the relations of the city with the company.

RICHMOND, VA.—Of the 116 miles of streets, 16.10 miles are occupied by the Richmond Passenger & Power Co. (franchise expires in January, 1930), and 11.24 miles by the Richmond Traction Co. (franchise expires in January, 1926). All rails and other materials used in the construction, repairing or relaying of tracks must be such as are satisfactory to the City Engineer. The company is required to pave between the tracks and for a width of 2 ft. outside; it must also keep up the paving, cleaning and repairing of streets having railway tracks. The arrangements for cleaning and sprinkling are subject to orders from the City Engineer and the Chief of Police. There is no trouble from electrolysis at present. The relations between the city and the company are under the control of the City Engineer, Mr. W. E. Cutshaw.

ROCKFORD, ILL.—The Rockford & Interurban Railway Co. has about 25 miles of track, and its franchise (granted in 1898) is for 25 years. The tracks must be in the middle of the streets. The company is required to pave and repair between the rails and tracks on paved streets, and to repair for 1 ft. outside the rails on unpaved streets. It must sprinkle the tracks and for 2 ft. outside, the city furnishing the water free; it may also contract for general street sprinkling. It must remove snow and ice from the tracks and then from the streets. The company is liable to the city for all damages due to electrolysis, and its relations with the city are subject to the orders of the Mayor and Superintendent of Streets. No freight traffic is permitted. Mr. Edwin Main is City Engineer.

ST. LOUIS, MO.—Street railway companies are required to pave between and for 18 ins. outside of the tracks with such material as may be designated by the street commissioner. They must also make their tracks conform to changes in street grades.

SAN FRANCISCO, CAL.—Here, as in Philadelphia, the companies pave the entire width of the street. The city charter provides that street railway franchises must require the companies to pave and keep in repair the streets from curb to curb.

SOUTH BEND, IND.—The lines are owned by the South Bend & Southern Michigan Ry. Co., which has an unlimited franchise and makes no financial reports to the city. There are 138 miles of street, of which 16.75 miles are occupied by the tracks. The city's regulations provide for the use of the tee rail, and state the size and spacing of ties, etc., but these are not very definite. The pavement of the tracks is the same as on the rest of the street, and the company is required to pay for a width of 7 ft. for single track, and between the tracks and for 3½ ft. each side of center along double track. It also keeps up the repairs along the tracks. There is no fran-

chise requirement as to street cleaning or sprinkling, but the company pays for sprinkling, and also removes snow. A 7-in., 70-lb. tee rail is used, 60 ft. long, double-bonded at the joints; the ties are of oak as a rule, 24 ins. c. to c. Concrete is laid between and upon the ties for pavements of asphalt or brick. There was trouble from electrolysis a few years ago, when the bonding was inefficient. The general operation is subject to the Board of Public Works, but the condition of track and overhead work, etc., is under the control of the City Engineer, Mr. A. J. Hammond.

SPRINGFIELD, ILL.—There is one street railway company, the Springfield Consolidated Ry., whose 20-year franchise expires Jan. 20, 1922. The company makes no financial report to the city. There are 135 miles of streets and 30 miles of street railway track. The city can require a flat or tee rail. When a street is paved the company must pave between the rails and for 1 ft. on each side with the same material as the street. It does not sprinkle or clean the tracks, but the company must repair the pavement when requested. In track construction tee rails are used, and the ties are laid on 6 ins. of stone ballast. Concrete foundations are used for the pavements. There is some trouble from electrolysis, but it has been greatly reduced by overhead returns. No grounds are used. The relations with the company are under the control of the City Engineer, Mr. Frank H. Hamilton.

WASHINGTON, D. C.—The street railways at present operating in the District of Columbia are the Capital Traction Co., the Washington, Alexandria & Mt. Vernon Ry. Co., and the Washington Ry. & Electric Co. The last is a managing corporation for 11 companies, operating under their respective charters. All of these are urban and interurban lines. The report of the Engineer Department of the District shows that in June, 1904, there were 238.10 miles of city streets and 203.57 miles of suburban streets. The street railway lines aggregated 65.80 miles of double track and 12.89 miles of single track (37 and 9.93 miles being on the conduit system).

The requirements as to financial reports set forth in the charter of the Capital Ry. Co. (which is considered a model charter) are as follows: The company must annually make a report to Congress (through the Commissioners of the District of Columbia), giving the names of all stockholders and the amount of stock held by each, together with a detailed statement of the receipts and expenditures. The company must also pay to the District annually 4% of its gross earnings, this being in place of taxes upon personal property, including cars and motive power; the tracks are not to be taxed as real estate. The same charter also requires that before commencing construction work in any street the company must deposit with the Treasurer of the United States such a sum as the Secretary of War may consider necessary to defray all the expenses that may be incurred by the United States in the inspection of the work and in making good any damages done by the company.

The following particulars are from a statement kindly furnished us by Major John Biddle, Corps of Engineers, U. S. Army, Engineer Commissioner of the District, to whom we are also indebted for the charter noted above and for other information:

Franchises are granted exclusively by Congress, in perpetuity, subject to forfeiture without judicial proceeding on failure to commence or complete within prescribed time. Abandonment for a period of three months and failure to remove the unused tracks within 60 days after notice by the authorities constitutes a misdemeanor with an attendant fine of $10 a day during the time such tracks remain in the street. The extent of the city's control in matter of track construction, paving, equipment and operation of roads is evidenced by the charters and by regulations based on general laws and embodied in the police regulations.

The paving of tracks of syndicate companies above named is done by the city's contractor under its supervision, and the cost is defrayed out of the company's deposit made for the purpose; the Capital Traction Co. does its work under arrangement with its own contractor. The width of track paving is fixed by charters and is the same as respects all roads, the character of paving as a rule conforming to that of the roadway. (For the Capital Ry. Co. the space between rails and tracks, and 2 ft. outside is required to be kept in repair.)

The style of rail used is fixed by law, which requires inside of city limits a flat grooved rail laid even with the surface of the roadway, so as not to present obstruction to vehicles; while a tee rail of approved pattern is allowed outside of city limits. All railways operating in the city employ the underground electric system, the use of the overhead trolley being prohibited except on the suburban roads, which use this system. Little trouble has been caused by electrolysis from the roads using the single trolley. Inside the fire limits an underground trolley with metallic circuit is allowed; outside the fire limits all newly built roads are required to have the overhead trolley without the grounded return.

The commissioners' (city's) relations with the companies are defined by their charters and by regulations framed thereunder and under general laws of Congress, which is the law-making body of the municipality and takes the place of the legislatures of the States.

TORONTO, CANADA.—The lines are all owned by the Toronto Ry. Co., which has a 20-year franchise, expiring in 1911. The company is required to pay to the city $800 per annum (payable quarterly) per mile of single track, and also to pay a percentage on its annual gross receipts as follows: 8% on gross receipts up to $1,000,000, 10% between $1,000,000 and $1,500,000, 12% to $2,000,000, 15% to $3,000,000, and 20% on all gross receipts over $3,000,000.

There are 265.26 miles of streets and 92.94 miles of single track and curves. The gage of tracks is specified as 4 ft. 11 ins., and the position and style of rail to be used and other works must be submitted to and approved in writing by the City Engineer. The rail now being used is a 90-lb. girder rail. The city does all paving, cleaning and sprinkling of streets, but the company is required to remove snow, as follows:

If the fall of snow is less than 6 ins. at any one time, the company must remove the same from the tracks and spaces hereinafter defined, and shall, if the city engineer so directs, evenly spread the snow on the adjoining portions of the roadway; but, should the quantity of snow or ice, etc., at any time exceed 6 ins. in depth, the whole space occupied as track allowances (viz., for double tracks, 16 ft. 6 ins., and for single tracks, 8 ft. 3 ins.) shall, if the city engineer so directs, be at once cleared of snow and ice, and the said material removed and deposited at such point or points on or off the street as may be ordered by the City Engineer.

There has not been much trouble from electrolysis, but one or two cases have been brought to the notice of the company. The company's relations with the city authorities are under the control of the City Engineer, Mr. C. H. Rust.

WINNIPEG, CANADA.—The lines are all owned by the Winnipeg Electric St. Ry. Co., whose tracks occupy 31 miles of streets, and which makes an annual statement to the city of its gross receipts. The company is required to pave a width of 8 ft. for single track, or 17 ft. for double track. A proportion of the repairs is also charged to the company, the repairs being done by the company or by the city on the company's account. The track construction and paving must be satisfactory to the City Engineer; street cleaning and sprinkling are done by the city. The present track construction comprises tee rails on ties laid in concrete. There is trouble from electrolysis, and the remedies applied are return wiring and bonding, but these are not satisfactory. The City Engineer, Mr. H. N. Ruttan, has control over the relations between the city and the company, to see that the charter provisions are carried out.

SOME DETAILS OF CITY BRIDGES.*

By Willis Whited,† Assoc. M. Am. Soc. C. E.

City bridge floors should, wherever practicable, be paved, if the traffic is heavy enough to justify it. Plank floors are expensive to keep in repair, besides being rough and unsightly after they are somewhat worn; they are also apt to break through and injure horses' legs. A durable, cheap floor consists of reinforced concrete slabs placed on the stringers, or cross [illegible] and covered with asphalt paving. This is somew[illegible] than plank floor, and rather more expens[illegible] cost of maintenance is so much less that [illegible] run it is more economical. It has the furthe[illegible] that it is water proof and prevents the drainag[illegible] roadway, which is quite corrosive, from [illegible] steelwork beneath. Other good methods of [illegible] floors are by buckled plates, and by beams [illegible] flat plates; these, like the reinforced concrete [illegible] be covered with any suitable paving; they al[illegible] better support for street rails if they are req[illegible] plank floor is used, white oak or yellow pine [illegible] joists. The flooring may be laid in two thick[illegible] the traffic is very heavy; the plank rots m[illegible] but is not so apt to break through. If the traf[illegible] a single thickness of plank is better and [illegible] should not generally be more than about 8 in[illegible] have so far been able to find no wood to co[illegible] white oak for this purpose. Good white oak [illegible] is becoming very scarce in this part of the c[illegible]

For paving, asphalt can be used if there are [illegible] car tracks and the grade does not exceed 4 or 5%, and the traffic is heavy enough to keep the asphalt in good order. Asphalt being only 3 ins. thick is lighter than any other paving. Some varieties of asphalt requiring no binder are only 2 ins. thick (the binder being 1 in. thick). If asphalt paving is used where there are street car tracks it is generally best to put a row of stone blocks on each side of the rails. Where the grade exceeds 4 or 5% and the traffic is very heavy, block stone is, perhaps, the only suitable material. Where the traffic is light, brick may be used. Wood blocks, which are better if creosoted, make an excellent pavement where the grade is not too heavy; they are much lighter than brick or stone and about as durable. They will stand a very heavy traffic and can be used next to street rails. All these pavements should be laid on concrete foundations, which may be reinforced if required to be laid as slabs. Masonry bridges should, of course, be paved the same as ordinary streets.

The sidewalks may be built of white oak plank, which should be laid crosswise of the bridge and about ¼-in. apart, and should be dressed to uniform thickness. If the spaces between them are wider than ¼-in. people can see through them to the ground or water beneath, and some nervous people cannot bear that. If the planks are laid lengthwise it is almost impossible to wheel a baby carriage across the bridge; besides, the ends lift up and people stumble over them. Cement is the best material for sidewalks with which I am acquainted. It can be laid as reinforced concrete slabs faced with mortar on [illegible] buckled plates. Asphalt was formerly much used but it is not so durable as cement, costs about as much, and if any steel work comes up through it contracts away from it, leaving a place where damp dust lodges and corrodes the steel work very rapidly. Cement, on the contrary, adheres closely to the steel and protects it from corrosion. If plank sidewalks are laid, it is well to protect the curbs with steel angles, about 4 × 3 × ⅜ ins., with the 3-in. leg turned down to form the curb and the 4-in. leg horizontal on top of the sidewalk plank, and secured to it by ½-in. lag screws about 2 ft. apart through the horizontal leg only. If they pass through the vertical leg, it is very difficult to get the curb angle loose to permit the putting in of new sidewalk planks owing to the fact that the screws rust firmly in the oak plank in a short time. If the sidewalk is of cement, which seldom occurs except where the roadway is paved, a cement curb is almost always the best. It is hardly ever necessary to face it with steel.

It is very important to thoroughly drain the spandrels of masonry bridges, especially where they cross over streets. They should be drained by means of pipes leading down through the piers into sewers. The backing of the arches should be made thoroughly water proof, preferably by a coating of strong cement mortar, asphalt is not durable in such places, and any leakage or drainage through the haunches of an arch produces dirty icicles in the winter, and unsightly incrustations in summer.

The railing of a bridge should be of sufficient height for protection but not so high but that a person can readily see over it. It is sometimes well to incline it considerably inwards at the top to prevent children from climbing over it, or it may be well to make the body of the railing of vertical parallel bars for the same reason. There should be no openings larger than about 6 ins. wide, otherwise small children might crawl through. If a stone railing is built the same rule should be observed as to openings, and the projecting coping at the top will prevent children climbing over it; the inside should be dressed so as not to injure the clothing of pedestrians; it is well to finish the top with a slope of about 30° so boys cannot walk on it. All railings, of course, should be of tasteful design, and not only be but also look substantial. Although very often done, it is seldom necessary to put a railing on the curb line; its principal service there generally is to furnish a roosting place for loafers.

*Extract from a paper read before the Engineers' Society of Western Pennsylvania, and printed in the society's Proceedings for February, 1906.

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Now that Gatun appears to be definitely adopted as the site of a dam across the Chagres valley to create an inland lake for a high level canal at Panama, it is of some interest to know who may be considered as the first engineer to suggest this site. It appears, from the Report of the Board of Consulting Engineers, that one of the many plans proposed at the International Scientific Congress at Paris in 1879 involved a dam at Gatun; but in the United States, Mr. Chas. D. Ward, M. Am. Soc. C. E., in a discussion before the American Society of Civil Engineers in 1880, appears to have made the original suggestion of a dam at Gatun. Concerning this project, the late Ashbel Welch, Past-President Am. Soc. C. E., in the same discussion in 1880 on De Lesseps' sea level plan, referring to Mr. Ward's proposal for a Gatun dam, said:

> The first thought of an American canal and river engineer, on looking at M. de Lesseps' raised map, is to convert the valley of the lower Chagres into an artificial lake, some 20 miles long, by a dam across the valley at or near the point where the proposed canal strikes it a few miles from Colon, such as was advocated by Mr. C. D. Ward.
>
> To avoid the expensive, dangerous and tedious canal proposed by M. de Lesseps, I would make such an artificial lake; its surface, say 80 ft. or more higher than the ocean, which, if M. de Lesseps' raised map is at all correct, would give a ship canal 40 or 50 ft. deep, and more than a quarter of a mile wide in the narrowest place. I hear the objection that the Chagres is a crooked stream, and could not be navigated by long ships. That is quite true. Of course, I would not merely slack-water the *river*. But the *valley* is direct, without sharp turns, and the ship channel would occupy the whole of that valley, not the mere bed of the stream that meanders through it. . . . .
>
> M. de Lesseps estimates the cost of his canal at $168,000,000. Most canals that I ever knew, or knew about, have cost very much more than the estimate. They cannot be estimated as railroads can, there are so many uncertain and unforeseen items, especially the very heavy item of pumping, and others arising from the work being so low down in or under the bottoms of the valleys. The Suez Canal, I understood, cost double the estimate. I should add 50% to the estimate named, making it $250,000,000.
>
> The locks and dam would save nearly all the artificial canal, some of it through rock cut for 20 miles along the Chagres; it would diminish the average deep cut, 7 miles long, from 180 ft. to 100 ft. deep, and decrease the cost of the rest of the work a good deal. I suppose it will hardly be questioned that the cost on the plan I propose would be 40% less than the thorough cut, that is, $150,000,000. I would not, in any case, dispense with the dam and reservoir to hold back the storm waters of the upper Chagres.

It is extremely interesting to see how closely those off-hand estimates of Mr. Welch, made more than a quarter century ago, correspond with the latest detailed figures for the sea-level and lock projects at Panama.

Mr. Ward appears to have still retained his interest in the canal project, and in 1904, in a paper before the American Society of Civil Engineers, he again brought forward his plan for a dam at Gatun in connection with a lock canal project.

The topography at Gatun and the possibility of locating a dam there appears to have attracted the attention independently of Major Cassius E. Gillette, who was stationed at the Isthmus during the interval between the departure of the French authorities and the taking over of the works by the Walker Commission of 1904. Major Gillette's plan for a lock canal with a dam at Gatun was published in our issue of July 27 last.

Finally Mr. John F. Stevens, who arrived on the Isthmus as Chief Engineer at about that time, said in his testimony before the Senate Committee on Jan. 23:

> The first time I went over the canal route I could see the force of the argument very readily about taking care of the Chagres River. I had understood from various writings that Bohio was the lowest point in the valley where the dam could be built. The first thing that occurred to me was: Is it a fact or is it an assumption? And on my way down I noted the narrow place in the valley at Gatun. I immediately asked some of my assistants why Bohio had been chosen for a dam-site instead of Gatun. They said the foundations at Bohio were better than at Gatun. I found, however, that there were no borings at Gatun, and that they did not know anything about it and I commenced to get ready to find out. About that time the Consulting Board cabled down instructions to go on with borings at Gatun—just what I was preparing to do—with the result that we have explained, that in the opinion of everyone, I think, Gatun has proved to be the better site.

A very interesting point brought out by Mr. Stevens, in his testimony before the Senate Committee, relates to the prospect of a better location for the regulating spillway from Lake Gatun than that proposed in the minority report, which we published last week. As our readers will remember, the present plan is to build a concrete spillway 800 ft. long with Stoney gates, as a part of the main dam. Mr. Stevens states that a recent reconnaissance up the Trinidad River (see map on p. 202 of our issue of Feb. 22) has shown a depression or pass in the hills only 27 ft. higher than the level of the future Lake Gatun. If the material there proves to be rock, as is expected, it will be easy and economical to locate here the spillway and regulating works by which the surplus waters of Lake Gatun will be discharged over the divide to the Atlantic. This will further simplify and economize the work of constructing the Gatun dam.

We note with interest that one of our technical contemporaries has embarked in a zealous crusade to discredit the plans for a lock canal at Panama. While it has failed thus far to print anything more than a brief summary of the minority report recommending the lock canal, it has devoted considerable space to its own arguments against the lock plan and in favor of the sea level plan.

So far as can be seen at present, the sea level plan appears to be, in the parlance of the day, "a dead one." None of the real friends of the canal in Congress appear to have any disposition to question or criticise the wise decision of the Canal Commission and the Executive adopting the lock canal. There is, however, still a chance, of course, that the interests which have long fought against any canal may take up the cudgels for the sea level plan, in the hope thus to postpone its completion to the far distant and uncertain future, and possibly to cause the ultimate abandonment of the work.

Our contemporary's arguments, for the most part, are mere threshing over old straw, and relate to matters so fully and authoritatively explained in the minority report that it would be a waste of space to notice them here. There are, however, two questions which it brings forward that have not been fully covered hitherto; and since they are questions which may have occurred also to some of our readers, we may properly discuss them here.

The first of these questions relates to the possible shoaling of the navigation channel in Lake Gatun by the sediment brought in by the tributary streams. Our contemporary says: "It is to be anticipated that troublesome shoalings, perhaps to a large extent, would take place in the vicinity of Obispo in consequence of this action."

Let us see, now, what may be reasonably "anticipated" as to the encroachment of silt on the navigation channel in Lake Gatun. If the reader will turn to the map of the lock canal, on page 202 of our issue of Feb. 22, he will see that all the streams that discharge into it are backed up far toward their headwaters, and, except the upper Chagres, not one has a flood discharge large enough to ever bring down sediment to the deep water in the center of the lake, where the sailing channel is located. We can confine our attention, therefore, to the Chagres alone. As seen by the map, the Gatun dam will back up the Chagres River nearly to Alhajuela, some *eight miles* away from the canal line. For four or five miles of this distance this arm of Lake Gatun will be a third of a mile to a mile in width; and even when the greatest recorded floods of the Chagres occur, there can be only a slow current in this long bay. Further, the Chagres and its tributaries coming into this bay are clear water streams of quick slope and their valleys have been swept clean of fine material by the floods of past eras. The coarse sand and gravel which are carried down by the upper Chagres in its floods will all be deposited near the upper end of the long bay extending from Alhajuela nearly to Gamboa. Practically no sediment of any consequence can come down as far as the canal line, for there will not be sufficient velocity to transport it.

In comparison with the ample provision which Lake Gatun furnishes for the sediment brought into it, we may contrast the proposition of the sea level projectors to permit a considerable number of streams, some of them with flood discharges of nearly 4,000 cu. ft. per second, to discharge directly into the canal and deposit all their sediment in the navigation channel, 150 ft. in width! The majority report frankly admitted that the maintenance of the channel would require dredging to remove these silt contributions.

So much for the silt question. Now for the other. Our contemporary sagely remarks that it has "endeavored to inform itself as thoroughly as possible regarding all features of this great canal problem." It then proceeds to criticise Messrs. Stearns, Noble et als. for their estimate of the cost of the lands which will be submerged by the future Lake Gatun. In place of that estimate of $7.70 per acre, our contemporary presents its own estimate of $250 to $1,000 per acre for the land submerged, or a total of "not less than $18,000,000 or $20,000,000 for the submerged land of the terminal lakes."

Now, we cannot pretend to any first-hand knowledge, even of the Poultney Bigelow order, as to the value per acre of Panama land. We have chanced to run across, however, an interesting bit of conversation in the examination of Chief Engineer Stevens by the Senate committee which bears directly upon the subject, and we print it verbatim, as follows:

> SENATOR SIMMONS.—Mr. Stevens, I understood you to say that the Gatun lake would flood about 118 sq. miles of territory. That would involve, of course, flooding a large amount of territory outside of the Canal Zone?
>
> MR. STEVENS.—Yes, sir.
>
> SENATOR SIMMONS.—All of that would have to be paid for by the Government?
>
> MR. STEVENS.—Yes, sir; the minority report contains an estimate of that. What I am about to state is altogether a coincidence, because, you understand, I knew nothing about either of these reports. In a general way I knew that the newspapers said that there was a division in the board; but in my spare time from my other duties I gave considerable time and interest to this matter, and that idea was one of the first that occurred to me—whether the plan for a big dam at Gatun would not flood so much valuable territory, millions and millions of dollars' worth of property, as to be out of the question.

But taking the Zone map, and taking the United States ownership, and including the Panama Railroad ownership, I figured that putting the value of the land as high as I possibly could, stretching my conscience to that extent (mind you, if I were buying there I would not pay any such prices) it would be necessary to acquire not to exceed $300,000 worth of privately owned tracts; and I find that the minority report have the same figures, although how they arrived at them I do not know.

SENATOR MORGAN.—I would like to remark that the treaty, as I understand it, settles all these questions by fixing the value of all property that is condemned at its value before the improvements were commenced.

SENATOR HOPKINS.—Yes; the treaty protects us in that respect.

SENATOR MORGAN.—Yes. That sum, of course, is a mere bagatelle.

SENATOR HOPKINS.—Well, Senator Simmons, as I understand what the treaty provides, it is this: Taking the amount of territory outside of the Zone that will be flooded, in determining the value of that territory between our Government and the Panama Government, the value of that land before this canal is touched is the value that will be fixed upon. We pay for it on a valuation prior to any improvements at all. As Mr. Stevens has said, we have the estimate both of himself and of the minority that it will be about $300,000, which is a mere bagatelle when you consider the other expenditures.

THE CHAIRMAN.—If you saw the conditions down there you would think Mr. Stevens's estimate was large enough.

MR. STEVENS.—The greater part of the land is a marsh. I do not believe that to-day there is on the Canal Zone, outside of the little towns and the railroad right-of-way, the equivalent of two square miles of cleared land.

SENATOR SIMMONS.—Mr. Stevens, I want to ask you this question: Beyond the flood line of this lake is there any settlement? Would there be any settlements out there?

MR. STEVENS.—There are none now, unless you go up the streams. I imagine there are some there. I never have been away up very many of them.

SENATOR GORMAN.—Mr. Stevens, I see that the minority report states that the 118 square miles of lake surface, on their lock plan, will require acquisitions of 20,480 acres of private ownership, and that the average cost of the land will be $7.70 an acre.

MR. STEVENS.—Yes.

SENATOR GORMAN.—That is rather insignificant. You would be compelled, according to this statement, to purchase land in either case—with either a lock or a sea-level canal.

In view of the facts and figures above set forth, we would mildly suggest that our esteemed contemporary go and inform itself some more.

An unusual argument for reinforced concrete as a structural material is presented in the notable example of hotel construction which we present in this issue. Here was a building which might as readily have been designed in steel and tile, and which, if so designed, would have been equally as cheap and fire-resisting and equally as rapid in construction in all probability as it has proved to be designed in reinforced concrete and tile, but which was designed in the latter material, partially at least, because it could be put in place without noise. If a steelwork frame had been chosen, riveting would have been necessary, and the sound of the riveter, it was feared, would drive away the fashionable guests of the adjacent hotel. It is safe to assume, however, that had the design adopted been unable to compete with steel and tile in economy, fireproofness and rapidity of construction, it would never have been used, despite its freedom from noise during construction. This is a fact that it is quite as well worth while to keep in mind as it is to note the less familiar one of noiselessness. It was because the concrete and tile construction compared favorably in the more important qualities mentioned, besides being comparatively noiseless in erection, that it was chosen.

If, as was the case in the work described, this combination construction of reinforced concrete and tile can be counted upon generally to compete on even terms with the fireproofed steel frame construction, it would appear that architects have in it a type of construction that possesses substantial merit. By the combination of ornamental terra cotta blocks and plain wall tile, the builder secures a wall construction that is weatherproof and soundproof to a remarkable degree that is exceptionally light in weight and that lends itself freely to decorative designs, and by the combination of reinforced concrete and hollow tile he has a floor construction that is notably strong and light in weight and that reduces the expense for forms to a minimum as compared with straight reinforced concrete slab and girder construction. In the matter of forms particularly the saving over straight reinforced concrete construction is worthy of special note. Curtain wall forms are, of course, altogether eliminated; and in the floor forms there is a substantial saving in material and labor, due, first, to the smaller number of girder forms required, and, second, to the simplification of the slab forms.

A rather notable feature of the work described is the roof construction; in this there was considerable variety of design and some particularly interesting dome work. Until recently, American practice has presented comparatively few examples of roof work of the more complex forms in reinforced concrete; most of the buildings erected in this material have been shops and factories or city business blocks, in which simple flat roofs sufficed. These involve no feature of design or construction different from ordinary slab and girder floor work. With European experience before them, very few engineers can have had much doubt that reinforced concrete would work out satisfactorily for more complex architectural roof forms; but their confidence in the truth of this fact must certainly be increased to the advantage of the art by such examples of actual construction as are furnished by the roof work of the Marlborough Hotel annex and of the Naval Academy chapel building, described in our issue of July 13, 1905.

There is at the present time no general or definite policy governing the relations between municipalities and street railway companies, but there is a very decided tendency towards enforcing the rights of the former (as owners of the streets) to a much greater extent than has been done in the past. The old idea has been pretty well exploded that the city should give away valuable franchise rights in perpetuity to a company which would give nothing in return except the establishment of rapid transit facilities, and with no provision for a future revision of the terms of the franchise under changed conditions. The recognition of the fact that the people have rights which have been abrogated by their representatives in the past is now giving rise to a strong movement in favor of revising the existing franchises on a more equitable basis, and the companies are being compelled to accept the revision, although not without a stubborn fight and an endeavor to effect at least a compromise. It is not improbable that in some cases the public has gone to the extreme and has had the "punishment" of the companies in view rather than the mere establishing of more equitable relations. For this, however, the companies must in some cases be largely held responsible, owing to their disregard of public rights and to derelictions in the way of poor service, neglect of street repairs, etc. In many cases, also, there has been an unnecessarily arbitrary attitude on the part of either the company or the municipal authorities, resulting in friction between them and in inharmonious relations which cannot conduce to public benefit or convenience. On another page we present information as to the conditions existing in a number of cities, and this may be read with interest in view of the present tendency towards revising the rights and privileges of public service companies.

It is an almost universal practice to require street railway companies to pave and maintain the paving between and for from 12 to 24 ins. outside of the rails and tracks, but it is not so universal to require the use of the same paving as is laid on the rest of the street. The cities of Philadelphia and San Francisco, however, are exceptional in requiring the companies to pave the full width of the streets between the curb lines. Of 20 cities having a population of over 200,000, 14 require the companies to do this street paving and repairing (including the two cities above mentioned); in two cities some lines are [illegible] others are not required to do this work, and in [illegible] cities the practice is indefinite or not uniform. Of 29 cities (including some of the smaller [illegible]ss), 22 require the companies to perform this work, one does not require it and two and four have mixed or indefinite practice as above. Twelve cities report that they exercise control over the form of rail and track construction, but in probably the majority of these cases the street railway company submits its plans, which are approved (perhaps with some modification) by the municipal authorities.

The resignation of Major C. E. Gillette from the Corps of Engineers is to be regretted from one point of view, for that body of engineers needs just such men as he, who combine high professional attainments with the executive ability and experience to successfully discharge large responsibilities. Under the circumstances, however, we are inclined to think that the immediate needs of the City of brotherly love—and corrupt politics—are enough greater than those of the United States to entirely justify Major Gillette in choosing the work there as a matter of duty. Had Congress seen fit to grant him permission for a longer leave of absence from the corps, he might have set matters right in Philadelphia without resigning his commission as was once done by another distinguished officer of the Corps of Engineers, the late Gen. Wm. Ludlow. There are, however, powerful interests in Philadelphia, with political influence extending as far as Washington, who preferred to have almost any other engineer than Gillette in charge of the Philadelphia work, and were probably responsible for the refusal of further leave of absence.

In commenting on the resignation, the "New York Times" remarks that the country is indebted to Major Gillette, rather than he to the country, and there can be no question, therefore, of his right to resign. To that statement we can give hearty approval. No one who did not follow in detail the exposure and conviction of Oberlin M. Carter can fully appreciate the heroic work that Major Gillette did eight years ago in bringing to justice as corrupt a set of rascals as ever conspired to loot the Treasury. It was quite as dirty and dangerous a task as swimming a muddy river under fire from the enemy and carried none of the rewards which accompanied the latter feat; but it lay in the line of duty and came in the day's work, and Gillette performed it with a fidelity and thoroughness which should long serve as an inspiring example to the whole engineering profession.

The task before him in his present position is in many respects quite as difficult and dangerous as that which he tackled at Savannah eight years ago, and it is to be hoped that he may have the support in its performance of all parties in Philadelphia who stand for honorable and honest municipal government.

THREE-CYLINDER COMPOUND LOCOMOTIVES IN ENGLAND.

The three-cylinder type of compond locomotive has been experimented with by a number of European railways, but it has never yet come into extensive use, except in the case of the London & Northwestern Ry. (England), and that road has now practically abandoned it, for reasons noted below. The cylinder arrangements in these designs have differed materially, some have had one and others two high-pressure cylinders, and the cylinders are connected to either one or two axles. The advantages of the three-cylinder type over the two-cylinder type are that it allows of a greater ratio of the cylinder volumes than is possible with the latter, while it gives a more uniform turning moment or rotative power. Its advantage over the four-cylinder type with four cranks is that there is less inside mechanism and consequently a little less weight with more room between the frames, allowing for larger bearings and giving greater accessibility with a less number of parts. While this may be of some practical advantage, its real

value does not seem to be very great, in view of the successful results obtained with several hundreds of four-cylinder engines having two inside cylinders with the necessary valve mechanism. Where the three cylinders have the same point of cut-off it is estimated that approximately 60% of the work will be done by the low-pressure engine (whether one or two low-pressure cylinders are used), but the proportion may be varied somewhat if the cut-off of the high and low-pressure cylinders can be adjusted independently.

At the Paris Exhibition of 1889 the Northern Ry. of France exhibited a mogul (2-6-0) three-cylinder compound having one inside high-pressure and two outside low-pressure cylinders, all connected to the middle driving axle. The two low-pressure cranks were set at right angles to each other, and the high-pressure crank was at 135° with them. Three-cylinder compounds of the ten-wheel type (4-6-0) for the Gotthard Ry., in 1895, had a similar arrangement of cylinders, but the inside cylinder drove the first axle and the outside cylinders drove the second axle, the three cranks being set at 120° (Engineering News, Sept. 12, 1895). Several other European railways have at different times built experimental three-cylinder compound locomotives with various arrangements of cylinders.

A Webb (English) engine was exhibited at the Chicago Exhibition in 1893 (Engineering News, Sept. 28, 1893) and one of the notable locomotives at the St. Louis Exhibition in 1904 was a German engine of special design (4-4-0), having three cylinders 20⅝ × 24⅞ ins. (Engineering News, Sept. 15, 1904). The high pressure (inside) cylinder was connected to the first driving axle, while the two low-pressure (outside) cylinders were connected to the second axle, the wheels being connected by coupling rods in the usual way. The two outside cranks were set parallel with each other and at 90° with the one inside crank. The coupling rod cranks on either side were at 90° with those on the opposite side, and at 45° with their respective outside driving cranks. The driving wheels were 86⅝ ins. diameter, and the weight was 195,800 lbs., with 74,800 lbs. on the driving wheels. This rather exceptional engine was one of two purchased by the Prussian State Railways for special high-speed service between Berlin and Hamburg; they were designed to haul trains of 180 tons at an average speed of 80½ miles an hour (including stops), and to attain a maximum speed of 93 miles an hour with lighter trains.

Three English railways are now experimenting with three-cylinder compounds for fast passenger service. On the Northeastern Ry. and the Midland Ry. (Engineering News, Aug. 1, 1901, and May 12, 1904) the engines are of the American type (4-4-0), with an inside high-pressure cylinder and two outside low-pressure cylinders, all connected to the first driving axle; the wheels, of course, are coupled. The Northeastern Ry. engines have an inside cylinder 19 × 26 ins. and two outside cylinders 20 × 24 ins. This use of different lengths of stroke is very unusual; the cranks are set as in the engine of the Northern Ry. of France, already mentioned. The Midland Ry. engines have cylinders 19 × 26 ins. and 21 × 26 ins., with driving wheels 84 ins. diameter. The latest line to take up the three-cylinder compound is the Great Central Ry., which has applied it to an engine of the Atlantic type (4-4-2), as noted in another column. This road, however, has adopted a cylinder arrangement similar to that of the German locomotive mentioned above, but the cylinder dimensions are not uniform, as in the latter. The inside high-pressure cylinder (19 × 26 ins.) drives the first, while the two outside low-pressure cylinders (21 × 26 ins.) drive the second driving axle. The wheels are smaller than in either of the other engines, being 81 ins. diameter, and they are connected by coupling rods. The engine weighs 71 gross tons, of which 37 tons are on the four driving wheels. No figures are as yet available in regard to the performance or the maintenance and running expenses of these three designs of compounds as compared with the practically identical simple engines in the same service, but they are said to be giving very favorable results.

Advantages are claimed for the two different plans of connecting the cylinders to one axle or to two axles, but the arguments seem to be in favor of the latter plan, especially in connection with the balancing and distribution of stresses. These arguments are also supported by the successful performance of some 2,000 four-cylinder balanced (or four-crank) compounds in Europe, which distribute the power through two axles instead of concentrating it upon one single axle and relying on the coupling rods for the transmission of power to the second axle.

In Mr. F. W. Webb's three-cylinder system two outside high-pressure cylinders drove the rear axle, while a single inside low-pressure cylinder drove the first axle, but a distinctive and peculiar feature of the Webb three-cylinder compound was the omission of coupling rods to connect the wheels driven by the high and low-pressure cylinders. This independence of the high and low-pressure engines was introduced even in freight engines having three driving axles, the rear wheels being coupled to the middle wheels, while there were no coupling rods between the front and middle wheels. This peculiarity seems to have been largely responsible for the unsatisfactory performance so persistently reported, and it has always been a disputed question as to what would have been the effect of fitting coupling rods to these engines.

The extensive use of Mr. Webb's compound locomotives on the London & Northwestern Ry. is an important feature in locomotive history, but there has always been some uncertainty as to their actual service economy; that is to say, in work done as well as in mere fuel consumption. This is really the prime test of any locomotive. A great deal has been written about them and they have some very high performance records to their credit, but little is definitely known from impartial and competent sources as to their fuel consumption under load, the repairs required, or the cost of maintenance and repairs in relation to similar items for comparable simple engines in the same service. In reliability and in capacity for meeting unusual demands for power, these compounds are reported to have been inferior to the simple engines. One of these Webb three-cylinder compounds (of the 2-4-0 class) was imported in 1889 by the Pennsylvania R. R. (Engineering News, Jan. 26, 1889) and in Wood's & Barnes' "Compound Locomotives" there is the following statement concerning this engine:

> The results of practical trial with the heavy trains used in the United States were satisfactory in economy but unsatisfactory in hauling power. It has been found difficult to start the ordinary weight of train with this engine, owing to the slipping of the driving wheels, which were not provided with parallel rods. When the trains are light the engine works with the most excellent economy, and shows a decided saving in fuel.

It is a rather significant fact that in the two years since Mr. Webb retired from the position of Superintendent of Motive Power his engines have been practically abandoned. In this particular respect history has repeated itself, as the same fate attended the two-cylinder compounds once extensively employed on the Northeastern Ry. When the inventor of the latter, Mr. Worsdell, retired from the road, his successor (and brother), the present Superintendent of Motive Power, adopted the policy of using all simple engines, although he is now experimenting on a small scale with a three-cylinder compound system, as already noted. In regard to the Webb engines on the London & Northwestern Ry., it appears from a recent article in "The Engineer," of London, that the compound freight engines are being converted into simple engines, while of 100 Webb passenger engines 72 have already been broken up and the remaining 28 will go to the scrap heap as soon as they are in condition to need heavy repairs. The article in question continues as follows, pointing out that the disappearance of these engines is not necessarily an argument against the three-cylinder compound principle in general:

> The Webb system, after 20 years' experience, has undergone decisive condemnation, mainly on the score of its untrustworthiness, but this untrustworthiness is not a necessary feature of the three-cylinder plan, but only of that particular mode of its application. The London & Northwestern three-cylinder compounds were constructed to work practically as two independent engines, and were so built that their wheels could not be coupled save at prohibitive cost, even if it had been clearly demonstrated that the high and low-pressure engines should work synchronously. Probably we shall never now know what Mr. Webb's engines could and would have done had their driving wheels been coupled, but it is undeniable that several of them performed at times work so good as to be distinctly remarkable. But the record of all the five classes of Webb three-cylinder compounds was too often marred by failure of one sort or another, particularly in starting, although it might have been supposed that the high-pressure cylinders would give a better starting impetus than would a single one of identical cubic dimensions.

One other point worth noting is the difference in the position of the compound locomotive in this country and in Europe. Here its design and introduction have been mainly in the hands of the locomotive builders, while there it has been pushed by the mechanical departments of the various railways. There are two reasons for this. In the first place, few American railways build their own locomotives, except perhaps some of the smaller classes in order to equalize the shop work. This condition is changing somewhat, as a number of important railways have established large new shop plants which are intended not only for repair work but to build a large proportion, if not all, of the new engines required. The principal reason, however, seems to be the fact that the English or foreign superintendent of motive power has greater authority and independence than are accorded to the same official on an American railway. Having this authority, and having a staff and plant not confined to repair work, the European mechanical officer has greater opportunity to design and build and alter engines of special design to meet the special conditions of traffic on his own road. It is worth noting that practically all the various compound locomotives in England have been designed by the railway officers and built at their own shops.

LETTERS TO THE EDITOR.

Vibrations in Large Gates for Deep Reservoirs.

Sir: This subject, discussed in Engineering News for Jan. 11 and referred to in Jan. 25, 1906, seems not yet to be conclusively cleared up. If any of the readers have actually observed violent vibrations of large gates under considerable head, it would be very interesting to know where, how the gates were constructed, and whether located in a tunnel or outside.

The observation of a fountain-jet under great head, rising through still air, has never revealed to the writer any remarkable pulsations in flow. That fluctuations in water pressure and the resulting pulsations in velocities, especially on great rivers and rivers near lakes, correspond to fluctuations in air pressure explains itself. To some extent the inertia and incompressibility of the body of water will necessitate such transmission without visible wave action at the place of observation.

The fact that trembling of dams is liable to be caused by a partial vacuum under the jet with interrupted access of air has not been disputed and should not be surprising. Hence, it appears that vent pipes will help to avoid one great and visible cause of the nuisance and the remainder of the chattering will probably prove harmless, if the same remedy as used for dams is applied for gates.

Very respectfully,
Charles R. Steiner.

U. S. Geol. Survey, Pathfinder, near Casper, Wyo.
Feb. 4, 1906.

Concerning Cement in Contact with Wood.

Sir: I would like to ask if it is an established fact that Portland cement mixtures coming in contact with wood, such as a wood floor laid over concrete, will cause the wood to completely decay [by what is commonly called dry rot] in the course of a few years.

If the above is a fact, what is the result to be of the so-called stucco houses where the cement is plastered on metal lath, the underside of which rests against the wood diagonal bracing, and where it comes in contact with the window casings?

Also, what will be the effect where it is plastered upon wood lath, both sides being plastered so that the lath is completely encased?

If the above is true, I should like to know the chemical actions causing the decay; lime mortar is supposed to be a preservative of wood.

Thanking you in advance for a reply.

Very truly yours,
Walter I. Insley.

48 Montague Place, Montclair, N. J., Feb. 26, 1906.

[It is undoubtedly true that wood not thoroughly seasoned and embedded in concrete may be destroyed by dry rot. It does not follow, however, that wooden houses covered with cement plaster will suffer, for the plaster is only in contact with the wood on one side, and the plaster on both the interior and exterior is porous enough as a rule to give fair ventilation to the interior space. Besides this, when cement mortar is used for plastering, it is almost invariably mixed with a considerable amount of lime, which acts as an antiseptic and preservative. On the other hand, it is a fact that the plaster coat, by its porosity, will allow moisture to pass through to the wood in a driving rain and will take some time to dry out. It is quite possible that under some circumstances this may promote decay. Regarding wood lath, we believe exterior plaster should never be laid on wood lath, as the lath will swell and shrink by alternate wetting and drying and will in time loosen the plaster.—Ed.]

Some Further Comments on the Austerlitz Bridge.

Sir: In the communication of Mr. K. A. Müllenhoff on the Austerlitz bridge in your issue of Feb. 1, there are a few statements made which we believe can stand some scrutiny.

Mr. Müllenhoff says: "I cannot consider it a drawback that such arches [with fixed ends] are statically indeterminate systems, for such systems offer no greater difficulty to a well trained engineer than any other system." Now, had he said that "the mathematics of such systems offer no greater difficulty," etc., there could, of course, be no exception taken, at least with reference to the American Engineer, thanks to his magnificent technical training (croakers will please take notice), for to him mathematical jugglery is an inviting pastime. No, it isn't the computations for stresses, rib shortening or deflections that alarm him, for after all these form almost an infinitesimal part of all the computations on a structure; but what he does balk at and, we trust, will always have the common sense to balk at, is the uncertainty of his results. Given an unyielding foundation, non-elastic masonry, perfect shop work, perfect engineering instruments, and possibly even a continuous girder would be justifiable; but given a pile foundation (and the majority of our bridges are so founded), imperfect shop work, imperfect engineering instruments, approximate theory, and the American Engineer values his sleep too much to recommend a second St. Louis bridge despite the excellence of that structure. Further, he has the impudence to believe that those structures he has built, despite the fact that their stability rarely depends upon the calculus, are structurally, even if not architecturally, fully as stable and economical as the calculus bridges of our German friends.

We imagine that the calculated deflection of 142.3 ins. (nearly 12 ft.) for the spandrel three-hinged arch of Fig. 1 with its span of 98.4 ft. (30 m.) and rise of 13.1 ft. (4 m.) would reduce to 5.6 ins. if the printer had put it down as millimeters instead of inches, otherwise it is no wonder that Mr. Müllenhoff dislikes a bridge that is capable of deflecting one-eighth of its span. The lack of stiffness in the three-hinged spandrel braced arch is, of course, well known. Such a type is better suited to light park structures than to railroad bridges. By using the three-hinged plate girder type and by making the girder deep and with heavy flanges, however, a rather stiff structure will result despite the center pin. The main fault with former designs of this type has been the shallowness of the girders whose depths should be from 3.5 to 4% of the span between end pins for a ratio of rise to span of from 1 to 8 to 1 to 10. In such a bridge economy of metal will result if the depth of the girder is varied with the moments. After erection with a center pin, heavy plates can be riveted over the central joint, making a two-hinged structure with statically determined dead stresses. The latest example of this method is the magnificent Cambridge, Mass., bridge just completed.

We do not believe the American Engineer is yet educated up to the point necessary for him to discover the great beauty of the Worm's bridge, in which the graceful arch effect is largely destroyed by the suspended floor. The horizontal line should be above, not below the arch. Such a structure looks unnecessarily heavy to support a comparatively light roadway.

B. J. T.

Washington, D. C., Feb. 3, 1906.

The Kauai Constant-Current Alternating Current Transmission, with Variable-Speed Water Wheels.

Sir: I note in the issue of your paper dated Feb. 1, 1906, page 126, an article entitled "A Variable Speed Water Power Plant with Constant Current Electric Transmission at Variable Voltage and Frequency." In the opening paragraph a regret is expressed that details of the plant are lacking, which prompts me to submit for your consideration the following additional details for the better understanding of the plant in question.

The Makee Sugar Co., of Kauai, H. T., controls a large acreage which has heretofore been barren, owing to the fact of its being situated above the irrigation canals on which the land is dependent for water during the greater part of the year. The principal irrigation canal on the island, carrying a large volume of water, is situated on the other side of the mountain from the ground to be irrigated, and at a considerable elevation. There is ample water below this land, but it is unavailable for lack of means to elevate it to the required height. The problem was solved by the application of hydraulic electric transmission, using the water from the large canal on one side of the mountain to develop power which is applied electrically to pumps on the other side, thus elevating the water to a sufficient height to irrigate the barren land. We have then a condition wherein the water of one watershed is the indirect means of irrigating the lands of another.

The water in the main canal is an extremely variable quantity, not only from one season to another but at different hours of the day; consequently, any transmission scheme must provide means for running pumps at highest efficiency at varying output, taking into account the fluctuation in the initial power due to varying the water supply. It is obvious that to accomplish this it was necessary to vary the speed of the electrically driven pumps in direct proportion to the varying power of the water wheels. This was accomplished by synchronous motors, which by varying the cycles according to the speed of the generator, are enabled to vary their power output and speed in the same proportion. This, of course, involves a corresponding change of water-wheel speed according to the water available, the wheels to run faster during the hours of greater water supply, and slower as this diminishes. In order to reduce the operating expenses to a minimum, an operator is in attendance at the generating station only, the resulting operations at the pumping plant being automatic.

The object of a variable speed plant is to obtain a variable voltage on the transmission line, which, in turn, results in a variable speed of induction motors. This speed variation secures an output from the pumps driven by the induction motors exactly corresponding with the power contained in the variable water which may be flowing at any period of time. The station attendant always aims to discharge the full amount of water available through the nozzles, operating the smallest diameter water wheel, which consequently runs at a proportionately higher speed and results in a greater power output. This regulation is accomplished at the power station some miles distant from the pumping station.

The hydraulic portion of the work consists of six Pelton water wheels of different diameters, each wheel being fitted with buckets designed for the special conditions of peripheral speed, water supply and power output involved, the static head being 390 ft. Each wheel is of such diameter and power capacity as to run the generator at the proper speed to correspond with the pump output, this being maintained at a maximum in accordance with the water used by the wheels. These six Pelton wheels are all mounted on the same shaft and arranged to run in the same wheel compartment, one at a time, the unit being direct connected to a single electric generator of 500 KW. capacity. Thus, the largest diameter wheel is to drive the generator at 280 r. p. m. and use 5 sec.-ft. of water, and the smallest at 450 r. p. m., using 8 sec.-ft. of water, the intermediate wheels running at intermediate speeds and using proportionate water quantity. Each wheel is supplied with a single stream of water through a nozzle of proper diameter, and the streams are controlled independently by a hydraulic gate operated through a special three-way valve. If the supply of water is falling off, as indicated to the station operator by gages, he closes the valve of the operating wheel and opens that of the next slower wheel and vice versa. These changes may occur several times a day, but it is always possible to deliver irrigating water to the higher levels in direct proportion to the supply water, thus obtaining the maximum daily efficiency and insuring the highest returns on investment. The variation in water wheel efficiency will be extremely slight if working at intermediate speeds between those for which the wheels are specifically calculated. The use of hydraulic gates for controlling the flow of water to each wheel makes the regulation extremely simple, and in addition to this method of controlling there is provided a stream cut-off on each nozzle operated from a common rockshaft. This, in turn, is controlled by a special device arranged to hold at any speed between 450 and 280 r. p. m., depending on the position at which the connecting belt may be set on cone pulleys.

The electric power is transmitted over the mountains to the pumping station, where synchronous motors are direct connected to Riedler pumps working against a head of 250 ft. The complete hydraulic equipment was furnished by the Pelton Water Wheel Co., of San Francisco, through the Allis-Chalmers Co., which furnished the electrical and pumping machinery.

Trusting that the above information will be of interest to you, I remain, yours truly,

Edward L. Bray,
Vice-President, The Pelton Water Wheel Co.
San Francisco, Cal., Feb. 13, 1906.

Concerning the Design of Grain Elevators and Other Storage Bins.

Sir: Referring to the inquiry of "Civil Engineer" in your issue of Jan. 11, in reference to calculation of stresses in bin structures and your accompanying editorial note:

The horizontal pressure exerted by any actually dry granular material stored in a bin, also the proportion of the weight carried by the bottom and by the bin walls or bin columns, may be accurately calculated as shown in the writer's paper, "The Pressure of Grain in Deep Bins," published in your columns March 10, 1904. Having ascertained the pressure and loads, all stresses in a properly designed bin may then be calculated with as little uncertainty as in any other structure. This, however, entirely depends upon the design, and to procure a safe and economical design requires a thorough knowledge of the pressures, distribution of the loads, and their practical application.

It is well known that over 75% of the bin structures built during the past few years of non-combustible materials have either partially or totally failed or shown decided evidence of weakness due to fundamentally wrong design, and this is largely because the designers have failed to recognize the important fact that friction, wall area, and ratio of depth to breadth, almost entirely control the pressures; that the pressures increase almost directly as the diameter; and that the walls acting as columns must carry the greater part of the grain load.

I agree with your advice to your correspondent that "the best way is to adopt such designs that complicated methods of computation involving large uncertainty in their practical application will not be required." I cannot, however, agree with you when you say that "as for the stresses in the walls, if circular bins are used, there will be nothing but tension in the concrete due to the bursting pressure of the grain." A moments consideration will clearly show that this cannot be true. Since grain produces much less pressure than a fluid of the same specific gravity, it is obvious that the walls acting as columns must carry part of the grain load. In deep bins the proportion thus carried by the walls will often amount to 85% of the total contents of the bin. The tank shell or wall is therefore subjected to a vertical compressive stress which in most cases is much greater than the tension due to the bursting pressure of the grain. In fact, it is quite practicable to build a standpipe or tank which would be quite safe when filled with water and yet fail under grain load. The writer knows of a number of steel tank structures which have a factor of safety of over 10 against bursting, which actually have partially or totally failed by shearing the rivets in the horizontal seams due to the excessive vertical load in the shell. Circular isolated tanks can, however, be made quite safe and the stresses accurately calculated, but practically they are uneconomical both as to cost and space.

With a view to economy many storage structures have been built with the circular tanks joined together and the star-shaped interspaces used for storage. This makes a structure in which it is impossible to even approximately calculate the stresses; in fact considering the interspaces, we have a bin the walls of which are four arches without abutments to resist the arch thrust. Several have failed from this cause, and most of this type are unsafe. In fact, circular bins for the storage of grain are simply a relic of the exploded fluid pressure theory.

With square bins there is no loss of space; they can be supported to the best advantage on columns, forming a working story in which cars may be placed for loading or unloading; the horizontal pressure of the grain in bins of moderate and practical size being small, the walls do not require great horizontal strength; each central wall forms a partition wall between two bins; and it is easy to provide strength to carry the vertical load. With good design they are the most economical and best meet practical conditions. They can be built of reinforced concrete and the strains can be calculated with very little uncertainty.

Many of the square bins that have been built to date have been constructed of flat steel plates with all joints riveted and strengthened by tie-bars. This style has not proved very successful. The flat plates have very little stiffness, the deflection is excessive, in many cases producing permanent set, and this permanent set is reversed as the bin on either side of a given wall is filled or emptied, thus greatly shortening the life of the structure. The tie-bars are often broken and pulled out by the frictional load of the moving columns of grain when the bin is being emptied. The stress in the walls due to the horizontal pressure and deflection of the plates,

intensified at the point of attachment of tie-bars, combined with the heavy accumulated vertical load, makes it impossible to even approximately calculate the stresses.

The writer believes that the only practical bin design, which is capable of exact computation of the stresses, is a square bin with walls constructed of a series of independent beams (steel trough-plate sections set on edge, with lock-bar between them to form a grain-tight joint) of sufficient strength and stiffness to resist the resultant grain pressures without the aid of tie-bars. The ends of the wall members are rigidly attached between column members located at the intersection of the wall of contiguous bins and forming a bin column of sufficient strength to carry the total accumulated loads direct to the foundations. The hopper-shaped bin bottoms are suspended from girders which carry this load alone. We thus have a bin structure in which there is no accumulated load carried by the walls, each wall member transferring its load to the columns in the same manner as the beams carry the floor loads to the columns in ordinary warehouse construction. The functions of each member are thus clearly defined and the stresses can therefore be accurately computed.

The designing of grain elevators or storage structures is an engineering specialty requiring knowledge and practical experience not usually possessed by engineers in general practice, and one into which practical considerations enter so largely that I would recommend "Civil Engineer" to study the problem very thoroughly before undertaking the design of this class of structure.

Yours truly,

J. A. Jamieson, M. Am. Soc. C. E.

Board of Trade Bldg., Montreal, Can., Feb. 6, 1906.

[Our comments attached to the letter of Feb. 11 were unfortunately too concise to be altogether accurate. The letter of our correspondent signed "Civil Engineer" appeared to refer to the difficulties of computing stresses in flat plates of rectangular or irregular shape, fixed around all or part of the perimeter, and loaded unsymmetrically, and our reply had this condition chiefly in mind. We are much indebted to Mr. Jamieson for his clear and forcible summary of the best current practice in bin designing.—Ed.]

An Engineer's Impressions of Brazil.

Sir: You have been kind enough to express a wish for some brief notes regarding my observations on a recent professional visit to Brazil, and I am writing on my knee in a railroad train in an effort to comply with your request.

The voyage from New York to Rio de Janeiro on the S. S. "Tennyson," of the Lamport & Holt Line, occupied 18 days, and was delightfully smooth and enjoyable throughout. One can scarcely imagine a more agreeable succession of lovely days. The return voyage was a repetition of the same experience, and I was told that this was nothing unusual or exceptional. If this be true the trip is one which should have great attractions for Americans as a voyage of rest and pleasure. We were 13 days out of sight of land before touching at Pernambuco (or Recife, as it is officially called), which is about 8° south of the equator. This is a well built city of 200,00 inhabitants, and called the Venice of Brazil on account of the quiet river winding through the place, spanned by numerous bridges. Some 400 miles further south we entered the spacious harbor of Bahia, on which is located the ancient Portuguese city of "San Salvador de la Bahia de Todos Santos," called Bahia for short. This was formerly the center of the African slave trade, and its population is largely made up of blacks, who predominate in numbers very decidedly. The population is said to be about 250,000. The city is built in two steps, the better and more modern portion being on the top of a bluff some 200 ft. or more in height, extending back into the interior over rolling ground, while the old part occupies a narrow strip of ground between the water's edge and the foot of the bluff, extending for several miles along the bay in this manner. The two portions of the city are connected by two incline cableways, laid on about 40% grade, obliquely to the face of the bluff, and also by an elevator in a tower reached by a short tunnel at the bottom and a bridge at the top. A few steep streets also ascend the hill. The streets are mostly very narrow, and in places the electric cars scrape the houses on one side, leaving a bare passage way for carts on the other. The city has very comfortable hotels, a handsome theater, innumerable churches, streets paved with stone blocks or cobbles, and it has a general air of bustle and activity. It is more quaint and foreign, more medieval one may say, than any city I saw in Brazil. Transportation of merchandise and every sort of commodity seems to be chiefly upon the heads of the negroes. For instance, I saw a grand piano being carried through a narrow street on the heads of six men, and was curious to watch them manoeuver to get by the street cars, sometimes having to back into an open doorway to let the cars pass. Even infants of two or three years were to be seen carrying little bundles on their heads.

The section devoted to the residences of the better classes would do credit to any North American city, for the beauty of its dwellings and the extreme neatness of its gardens, blazing with rarest flowers. A favorite decoration seemed to be pine apples growing in pots on the tops of the massive stone gate-posts. For a city where the negro is in control of the municipal and state governments and generally in the majority Bahia has unusual attractions and interest.

Seven hundred miles further down the coast lies the city of Rio de Janeiro, containing 1,000,000 inhabitants. Rio is famous the world over for its beautiful harbor, and too much cannot be said in its praise, for surely no situation could be more picturesque. The most striking object in the landscape as you approach is Sugar Loaf peak at the harbor entrance, 900 ft. high, but this is overshadowed by Corconado peak, a granite crag with sheer front, 2,500 ft. high, around the base of which a good part of the city is built. The peak is ascended by a rack railway, on grades of 30% to 35%, built through a tropical forest. The crest of the peak is about as large as an ordinary parlor and surrounded by a parapet wall for safety, as its sides are perpendicular.

The architecture of Rio is strikingly like the Italian, particularly in its dwellings and villas, where cool effects are sought. The exterior walls are sometimes gayly decorated with paintings of landscapes, human figures and flowers, particularly under the ground glass awnings of porches.

One cannot but be impressed with the extraordinary beauty of the granite which is universally used for door and window casings and for foundations, and frequently for the entire house. It is mottled and as handsome as agate or scagliola. Granite abounds everywhere in Brazil, and as far as I travelled I saw no other stone. It is deeply disintegrated in places, as could be expected in the tropics where carbonic acid is freed from the rank vegetation in such constant quantities. The Brazilians are expert stone cutters, and they make the most wonderful dry walls of stone ever seen, veritable mosaics, absolutely smooth and true on the surface, with every void between large stones filled with spawls brought to the same line. These dry walls are to be seen along the railways, used for retaining walls, and frequently dwellings are thus built without mortar.

Rio is well supplied with street railways, although they are mostly mule-propelled. These, however, are soon to give way to the march of progress and be electrified and reconstructed, as all the mule-car lines have been purchased by the Rio de Janeiro Tramway, Light & Power Co., Limited, a Canadian corporation composed chiefly of Toronto and Montreal capitalists, who are investing $50,000,000 gold in their enterprise. These capitalists will control the lighting of the city, as they have purchased the gas works and have an exclusive franchise for electric lighting. They are developing 40,000 HP. on the Rio das Lages at a point about 50 miles in the interior, which will be transmitted to the city on a modern transmission line supported by galvanized steel towers. To reach the power station they have built a branch from the Central Railroad of Brazil, 20 kilometers long, for the purpose of delivering machinery and supplies. They utilize a drop of 950 ft. with a normal flow of 350 cu. ft. per sec., and a conduit capacity for overload of 20 cu. m. per sec., or about 700 sec.-ft. To equalize the stream they are building a concrete masonry dam at the head of the falls, to be 135 ft. high, 700 ft. long on crest, curved in plan with a radius of 85 meters, and having a gravity section of the Wegmann type of profile. The reservoir will be 20 miles long and have a capacity of 100,000,000 cu. m. (about 3,530,000,000 cu. ft. From this reservoir the conduit will consist of a masonry lined canal, and two tunnels with a total length of two kilometers to the head of the power drop, where a petty reservoir will be constructed.

The company is reconstructing and enlarging its gas plant under the plans of Mr. A. B. Slater, of New York, Consulting Gas Engineer.

Up to the present time the city of Rio de Janeiro has had no wharves or docks at which vessels could unload, but all merchandise is handled by slow and costly lighterage to and from vessels anchored in the harbor. This is to be done away with, however, for the Brazilian Government is expending $40,000,000 in the construction of new docks, and a general improvement of its water front. A part of this comprehensive plan is a grand parked boulevard extending for many miles around the city front, with a sea-wall and handsome parapet surmounting it. This wall curves gracefully about the headlands and bays, cutting off many indentations and reclaiming considerable areas now covered with water. When this is done Rio will be one of the most beautiful capitals in the world. The boulevard cuts across a peninsula about two miles wide, through the heart of the business portion, where a general demolition of houses has taken place, as radical an improvement as Napoleon made in Paris. This avenue bids fair to be as beautiful and as brilliantly lighted as the Champs Elyseé, or the Place de la Concorde. The city is now torn up from end to end with these improvements.

The contrast between the Rua de Ouvidor, which is the popular shopping street of Rio, but is only about 16 ft. wide, and the new Avenida Central, with a width of 125 ft., as I recollect, will be very marked. The new avenue is being paved with asphalt blocks, laid on concrete.

Brazil has an extensive railway system extending from the principal ports into the interior, but these are not connected to any great extent, and the ocean is still the principal highway. The two largest cities, Rio Janeiro and Sao Paulo, are but 300 miles apart and are joined by rail, but the road is of two gages, and a transfer must be made at an intermediate point. The discomforts of this journey are only equalled by the trip from Milan to Genoa, in Italy, or by a ride in a freight caboose across the Western plains of the United States. The rates are exorbitant and the service abominable. The one Pullman car run on this line was built in some former generation when sleeping cars were first invented, and is as cramped and inconvenient as it is dirty and uncomfortable; while the dust was frightful. The road is run by the Government and has an enormous income, which is absorbed in maintaining its 12,000 employees in fat places.

Sao Paulo is a prosperous, modern city of 300,000 inhabitants, which has doubled its population in the last five years. Much of the impetus for this growth was due to the development of the Sao Paulo Tramway, Light & Power Co., Limited, another Toronto corporation. This company built a fine power plant on the Tieté river, 23 miles below Sao Paulo (which is located on the same stream), some five years ago, and transmits 10,000 to 15,000 HP. to the city. A masonry dam about 40 ft. high was built across the river, and the water conducted 2,300 ft. through two 12-ft. steel pipes to the power-house, where a drop of 77 ft. is utilized. To partially equalize the stream and conserve water to make up for an annual shortage in the months of August and September, they are now engaged in building a dam across a branch of the river above Sao Paulo to form a reservoir of 150,000,000 cu. m. capacity. This dam will be built by the hydraulic sluicing process, with the sole agency of water pumped under high pressure from the stream. The dam will be 2,000 ft. long and 40 ft. high, and the reservoir will cover 5,000 to 6,000 acres.

The city of Sao Paulo is now provided with a network of electric railways, with modern cars, giving first class service, and is also well lighted.

Sao Paulo is the center of the principal coffee trade of Brazil, the most extensive plantations of the country being in the interior to the west of the city. The elevation of Sao Paulo is about 2,500 ft. above sea level, and 50 miles distant from the port of Santos with which it is connected by railway built and operated by an English company. It is one of the older roads of the country and built very substantially throughout. The station at Sao Paulo is a very handsome building, said to have cost $2,500,000. It would do credit to any American city of double the population. The road is operated by cables over five miles of the ascent of the Serra, with stationary engines of 1,000 HP. one mile apart. The grades in this section are about 8%. The foot of the incline is 20 miles from Santos. This portion of the road was recently rebuilt, with new power houses and equipment on a location parallel to the old line, but with less gradient than the first construction. The old incline is, however, maintained in good order, ready for service in case of emergency. The scenic beauty of this road over the Serra, through tropical jungles and forests, cannot well be described.

The climate of Sao Paulo is very salubrious, quite like that of Southern California (though much more moist), notwithstanding that it lies on the tropic of Capricorn.

The city of Santos may well be proud of its five miles of cut stone docks, at which vessels of any draft may tie up and be loaded and unloaded with modern cranes operated by compressed air. The harbor is land locked, and though small is better sheltered from storms than those of Rio or Bahia. The city has about 30,000 inhabitants and a climate which is thoroughly tropical. It is substantially built and has some handsome houses. It was once a hotbed of yellow fever, but since the building of the docks and the filling of the low ground behind them no cases of fever have appeared. Coffee is the staple article of traffic and it is claimed that more coffee is handled in Santos than at any other port in the world.

The Brazilians appear to be prosperous, industrious and well-to-do. In all the cities visited there were no evidences of beggary or extreme poverty. They also appear to be honest and there is a refreshing absence of burglary and petty thievery, which gives one a sense of absolute security in traveling through the country.

The currency of the country is paper and nickel; no silver or gold being in evidence. The paper money is circulated until it is so ragged, torn and greasy that it will no longer hold together, and is regarded as good so long as its denomination is legible. The value of the milreis fluctuates daily with the varying price of exchange in London, and when you offer an American or English gold piece in payment of a purchase the merchant must first consult the morning paper to see what the price of exchange is for that day. During the two weeks of our stay the value of the milreis varied from

15 to 17 pence, an average of about 33 cts. of American money. It is sometimes as low as 10 cts. and as high as 60 cts. As prices of merchandise do not vary correspondingly, foreign employees of banks and other business houses who are paid in gold are in constant uncertainty as to the cost of living.

In Brazil there appear to be but two classes, the educated and wealthy class and the poor laboring class. The upper class, of course, controls the politics, and freedom of the ballot is unknown. Common labor is paid at the rate of about three milreis per day.

Duties are levied on all importations at a high rate, and the cost of all articles of clothing, furniture and the usual necessaries of life is two to three times as great as in the United States.

The foreign trade of the country is chiefly with European merchants, German, English, Italian and French, in about the order named. While the United States pays Brazil about $50,000,000 a year for coffee, we sell them only about $20,000,000 worth of our produce and manufactures. The cargo of our steamer from New York chiefly consisted of kerosene oil.

From the very general and superficial knowledge of a country as vast as Brazil to be gained by a stay of two weeks in the cities along its seaboard, one cannot be expected to form profound conclusions, but from such observations as I was able to make I received the impression that it is a country of vast and varied natural resources, as yet but little developed, or explored, but not offering brilliant inducements for any North American to leave his home and country with the expectation of bettering his condition. "The United States are good enough for me" is a sentiment frequently expressed by Americans in Brazil, and one to which I cordially subscribe. Jas. D. Schuyler.

En route to City of Mexico, Jan. 4, 1906.

Filing Methods for Engineers in Private Practice.

Sir: I note in your issue of Jan. 4, 1906, an inquiry as to the filing of maps, etc. While my system may not be adapted to a large office, with an extensive practice, I thought that a description of the same might be of interest, as I have found it very convenient to my own needs.

In numbering and designing maps and plans I use the year, month and day for the serial number: 50723 was completed July 23, 1905. These numbers are followed by letters: D = original drawing, T = tracing, M = finished map. In connection with these, the letter X is used. Preceding them, it indicates a copy made in the office from a source outside the office; succeeding, a map made outside of the office. Thus: 20706XT means a tracing made July 6, 1902, from a map supplied by John Doe; 41102DX means a map supplied and filed in the office, made by Richard Roe.

New as to folding. It takes nerve to fold a drawing, but most of them can be folded if one makes up his mind to do so. Over half of my drawings are folded so as to be placed in legal cap filing boxes, on the back of which are the limiting numbers. On the lower right hand corner of each folded map is its number and in the left hand lower corner the reference words.

Maps that cannot be folded, and especially tracings from which it is expected that prints will be required, are filed in cloth-covered telescoping tubes. Three lengths are used, 36, 42 and 48 ins., which are lettered, respectively, A,B, to A2, B2, &c.; 2A, 2B, to 2A2, 2B2, &c.; 3A, 3B, to 3A2, 3B2, &c. The diameters range from 2 to 6 ins. Each map filed in these tubes bears the letter of the tube in which it belongs. It also bears the full title of the finished drawing and words underscored indicating the cards under which it is indexed.

A card index is kept and a blank book to fit the card index drawer, in which latter the titles are entered chronologically, the same words being underscored. Some maps require but one reference, others more: usually it is the name of the party for whom the work was done and the location. Then sometimes there are special titles requiring indexing, such as Mine Maps, City Lots, Culverts, Foundations. On the cards and in the book, the references to the tubes are in pencil.

In the book index, the titles are entered in pencil at the time the work is done, and the maps filed in the "Unindexed" tube or file box. When time is convenient, and at not too long intervals, the cards are made out and filed, the penciling is inked, and the maps properly placed.

Each tube will hold quite a number of maps, but too many should not be placed therein, thus rendering a search bothersome. A house cleaning can be made about once a year, when it will be discovered that a large number can be folded for placing in the boxes. At this time the underscored words will be useful in locating the cards, and the pencil references to tubes in book index and on cards can be erased.

The filing boxes can be kept upright on a shelf. The tubes can be disposed of according to your own preference and office accommodations. My tubes stand upright in a sort of perpendicular pigeon holes, each opening of which can accommodate a half dozen or more tubes.

W. D. Sell, Assoc. Am. Soc. C. E.

Charleston, W. Va., Jan. 8, 1906.

Sir: It is useless to attempt to keep maps, notes and records if no method is adopted for filing them quickly. Usually they are wanted when time is pressing. The writer has solved the problem to his own satisfaction in the manner described below.

The first thing to do is to provide for taking care of the papers after classification. The second is to avoid complex classification in the filing receptacles. The third is to provide an adequate index and do all the classifying there.

Some men have a mania—or develop one—for minute subdivision and classification and devise a system (so-called) that is burdensome and acts as a deterent upon friends who see it in operation. Complex systems are soon abandoned unless the engineer is fortunate enough to be able to indulge in the luxury of an index clerk. An ordinary office boy cannot index the papers of an engineer.

DRAWINGS.—A sheet of paper 36 ins. wide can be divided most economically by adhering to the following regular sizes of sheets, which are lettered to indicate the size: "A" sheets, 9 × 12 ins.; "B" sheets, 12 × 18 ins.; "C" sheets, 18 × 24 ins.; "D" sheets, 24 × 36 ins. Sheets between these sizes are to be lettered to correspond and be filed with sheets of the next size larger.

The sheets are to be filed by size in drawers or filing cases. They can also be filed in home-made portfolios, and these can be hung on a wall or partition or placed on shelves.

Many drawings will have to be kept in rolls, for some will be too large to file conveniently in drawers and some must be taken out of the office often. It is the practice of the writer to keep all drawings rolled up that are handled frequently outside the office. The rolled drawings are kept in pasteboard cases. These cases can be purchased from any dealer in drawing materials, but local box factories will usually make them in dozen lots for a much lower price.

The rolled drawings are naturally divided into two classes: (1) Drawings larger than 24 × 36 ins., and to which a letter can be given according to their width. The following are suggestive: "E" sheets are 30 ins. wide and may be of any length, provided they are too large to be classified with "D" sheets; "F" sheets, 36 ins. wide; "G" sheets, 42 ins.; "H" sheets, 48 ins., etc., each letter being for sheets 6 ins. or less wider than the next smaller sheet. The width of the sheet regulates the length of the filing tube or case. (2) Drawings in use on some particular job and kept together until the job is completed are usually placed in tubes of a smaller diameter than the regular tubes, for convenience, and only one set is kept in a tube. A label is pasted on the tube so it can be readily kept track of.

The most satisfactory method for taking care of the tubes, considering economy and ease of reference, is to have a framework built in the office, much like the studding in house framing. In each vertical post drive wooden pegs at a slight angle, long enough to hold about two or three tubes on each peg. In order that prying visitors may not become too interested in work going on in the office it is good practice to number every job consecutively and place only the number on the label pasted on the tubes containing work in hand.

The first class of drawings will be usually on paper or tracing cloth. The second class usually consists solely of blue prints. The second class will be indexed in the permanent index record, so far as the original drawings are concerned, from which the blue prints are made. An additional index for work in hand is therefore a simple matter.

A book with plain pages and having an alphabetical index is used. Each job is numbered consecutively and a record entered in the book, commencing with the first page. Usually a page is given to each job.

First the number of the job is placed at the upper outside corner of the page. Underneath is placed the name and address of the party for whom the work is being done and such other items (including dates) as may be considered necessary to keep the record compact and fairly complete. Below this put a list of the drawings used for the work, together with their index and filing numbers. In the alphabetical index forming a part of the book it is simply necessary to put in the name of the employer (client), together with the job number and the page of the record. The cost of the tubes is so small that it pays to keep all the drawings, together with specifications, contract, etc., in these same tubes and file them away when the job is done. If any question afterwards arises the ability to produce such papers when wanted is a valuable asset. The writer usually seals the tubes and puts them where the dust cannot accumulate and where there will be small danger of fire.

An engineer should have a fireproof safe, or rather a good-sized vault, in his office and keep all the records in it. If he cannot do this, but must carry them to a vault for storage each night, he will find [illegible] and flat portfolios better than shallow drawers [illegible] standard filing cases. Metal-protected filing cases [illegible] of course be purchased if the engineer can afford it.

PERMANENT CARD INDEX.—The perm[illegible]t index is used for keeping track of field books, [illegible]culation books and drawings, maps, plans, sketches, [illegible]. It is best to use for this purpose regular index [illegible] now so common a feature in office record systems. [illegible]s 3 × 5 ins. in a 120 division of the alphabet are [illegible]y convenient. On this part of his outfit the engi[illegible] can go to any expense he wishes. The writer uses [illegible]pboard filing box costing him 30 cts. His cards [illegible]cts. per 100 and the alphabetical guide cards cost 80 [illegible] per set. As the filing box was prepared only for fi[illegible] cards it had no guide to maintain cards in an erect po[illegible]on when the box is partly filled. The guide, however, [illegible] an easy and inexpensive matter to arrange. The box will hold 1,500 cards, in addition to the guide cards. The above figures are given to show that the cost of th[illegible] index is not too high to prevent its use. The man who wishes to have a finely finished wooden case with trimmings can get it by paying the price.

Each job is indexed in the card index by the name of the client. The full name is put at the top, together with the job number. On the lines beneath are placed the numbers of all the drawings, followed by an identifying description, precisely as in the reference book for work in hand. This card also contains the numbers, etc., by which to identify the field and calculation books used on the work.

To avoid duplication of numbers all books used are numbered consecutively, transit books being indicated in the index by "T," level books by "L" and books used in the office by "O." The letter and number placed on the back, where it can be seen when the book is on a shelf, indicates to the searcher the book wanted.

Office books are two in kind. One kind is about the same in size as a field book, but costs much less, and when possible all the pages should be ruled in squares. The other office books are usually about 8½ ins. wide and 14 ins. high. The pages are also ruled in squares. The squares may be eight or ten to the inch. When doing any figuring it is wisest to do it in a book instead of on slips of paper to be thrown away. A slight degree of care used to indicate at the top of the page the work done thereon, and a careful indexing of the book, will often save considerable annoyance and expense afterwards. The writer, for this reason, when in the field prefers to do his figuring on pages of the field book rather than on separate pads; if it cannot be done without interfering with the notes on an opposite page, then he figures in the back of the book.

In any scheme for indexing plats, etc., the letters "T," "L" and "O" are kept for the books. The books are not numbered with the number of the piece of work, for frequently one book may be used on several jobs and, conversely, some pieces of work will use up many books. It happens occasionally that one book may be used for both transit and level work. In that case it is filed as a transit book.

It has been mentioned that each job is indexed by name of client in the alphabetical index. It is also indexed by the number in the same index. The number is placed at the upper left hand corner of the card and the name of the client is put beneath. Then for information the seeker will look up the card containing the name of the client. All the data in the field and office books is indexed by name of client, name of work, name of street and in fact by as many cross references as the indexer cares to use. Bench marks, monuments and all survey points are indexed in the same way.

The writer prefers to use a single index, instead of having one for each subject or class of work.

So far as the use of books is concerned, the writer prefers to have in books only data used or collected. For records he prefers loose sheets, 9 × 12 ins., or as much larger as may be found necessary. On these sheets can be plotted all the information wanted in much better shape than it can be placed in a bound book. It helps, also, in making records to be able to plot to scale, and this it is almost impossible to do in a bound book. The card index finds these sheets as quickly as it will find a book.

It may be objected to that such a system as is here described lumps things too much, and it would facilitate matters to classify each subject in drawers or portfolios. The writer has seen many men abandon system altogether after making attempts at such classification, because it is hard to keep up and calls for too much indexing. In the system described the most economical methods so far as space is concerned, are considered. It has been a matter of growth.

In the card index any degree of classification can be carried out. For example, cards can be headed Benches, Monuments, etc., and reference made to streets and books and plats, to one or all. Water-works, Sewerage, Street Improvements, etc., can be referred to also under a general heading and cross referenced as minutely as desired.

Whenever a drawing is traced or a copy [illegible]en out remarks can be written on the back of the sheet. Each

tracing will carry the number of the drawing, and if the drawing was entirely on tracing cloth it is a good plan to put in the file with it a sheet attached to it by a clasp or pin. The sheet of paper should of course carry the same letter and number, so it can be put back in place if detached at any time the tracing is used. On this sheet should be put all remarks likely to be of value, such as dates when blue prints were made, to whom given, alterations, etc. When drawings are changed so much that a new one is required, the new drawing should carry the old number and letter (if of the same size) and have on it memoranda to indicate the changes. The old drawing should be marked across the face in large letters "Cancelled by drawing ——." By doing this all drawings can be kept together without danger, as it is not good policy to throw such things away when replaced by new drawings. The writer has found it well sometimes to put old changed drawings away in tubes bearing the letter of the sheet size so that the flat files or drawers will not have too much old matter in them.

Sometimes for convenience on certain work a slight dropping into a decimal system of filing is adopted. Take, for example, a sewer system in Jonesboro. The drawings will be on sheets of different sizes, and in the upper left hand corner will appear perhaps as A 667, B 591, C 245, D 127 and the general map may be F 90. Underneath is the number of the job, the whole being in the form of a fraction. Pipe details will be No. 1 throughout for record purposes for that particular job. Manholes (general) will be No. 2. Manhole details will be 2.1, 2.2, 2.3, etc., and 2.21 if there are details of details, etc. Catch basins will be No. 3, flush tanks, No. 4, etc. The reason for this is that sometimes special records are made for each job, and besides that an engineer in the course of long practice will be sure to accumulate standards. Of these standards he can have a special and separate index, and throughout he can give certain details definite recognition numbers. Such a matter can be best developed by the man using the system.

It is assumed that the index referred to relates solely to matter placed on sheets and to the accompanying data in books. It possesses an admirable flexibility and is therefore capable of indefinite expansion. The engineer, however, has other things to preserve and another index should be provided for them.

LOOSE LEAF INDEX SYSTEM FOR NOTES, ETC.—In the course of time sketches, notes of observation, trade secrets, useful wrinkles and formulas accumulate and should be so preserved that they will be immediately available when wanted. It is a good plan to carry a loose leaf book with ruled pages and make such notes and memoranda on the loose sheets. Each item should be placed under a heading, so it can be found with certainty when wanted, and it is a good plan to put at the top of the sheet all the headings under which the subject might be looked for when wanted. When back in the office the sheets should be taken from the covers and filed alphabetically in a box of the proper size. Where several headings are indicated, make out blank sheets containing that subject at the head and underneath a statement as to the heading under which the information is filed. These auxiliary sheets are to be filed alphabetically. It can be readily seen that such a system is self-indexing and calls for no additional work in recording, provided only one subject is entered on each page. The engineer has thus a constantly expanding, self-indexed hand book of data. It is not of course one he can carry with him in his pocket, but it is one he can easily refer to in the office.

TRADE LITERATURE.—A description of filing and indexing methods for the office of an engineer in private practice would not be complete without reference to the preservation of trade literature. Some of it is of a high class and worthy of preservation and careful indexing. The writer indexes by the name of the firm and by the principal articles mentioned. Some of the pamphlets are indexed by all the articles referred to and sometimes a copy is made of the index of the pamphlet or catalogue itself. The fulness of the index depends upon the character and probable future value of the publication.

A card index is provided for this material, which is entirely separate from the card index used for recording work done. Filing cases of the right size to take the papers readily are used, and they are numbered consecutively. Each pamphlet, or catalogue, is given the number of the case it goes into, and underneath is a serial number which tells at a glance the number of pamphlets filed. While this latter is not absolutely essential, it adds to the convenience of reference to the publication, and it is also useful for statistical purposes.

It is well to put in these cases all fragmentary literature obtained from all sources, such as clippings from papers and magazines, occasional volumes of society proceedings, etc. Clippings are usually pasted on sheets of paper and put into envelopes. Sometimes they are pasted into scrap books, put on the shelves with the filing cases and numbered with them. No separate classification is attempted. The trade literature is coming in every day and one book contains so many items it is impossible to make a classification on the shelves. It is best and simplest to make it in the index.

Pamphlet filing cases can be purchased that look well on a shelf, being made with book-imitation backs. They cost from $3 to $4 per dozen. The writer has used pasteboard cases, made by paper box makers and book binders at a cost of from 15 to 20 cts. each. They are 3 ins. wide, 7 ins. high, and at the open end are 11 ins. long on the bottom and 7 ins. long on top. The pamphlets therefore are on their sides.

For larger catalogues special sizes have to be made. The filing transfer cases made for the Shannon system of filing letters are very good when purchased without the attachments to which the letters are fastened when transferred. They consist of a case, open at one end, into which fits a piece of pasteboard bent to form two sides and one end.

The writer has adopted, and intends holding to, cheap letter files that can be purchased in any stationery store for from 15 to 20 cts. each. He prepares them by removing the index sheets, putting in a division of cigar box wood to make two filing spaces, and placing them like drawers in a case made for them. The inside dimensions are 10 by 12 ins., and putting a division in the middle gives two compartments a trifle less than 5 ins. wide by 10 ins. long. Every catalogue that will fit into such a space is put there. Sometimes a little trimming of edges is necessary. Generally the division is made so that one side will be 6½ ins. wide by 10 ins. in length. On the outside of the file is marked the width of the division, so that the indexer can tell at a glance whether the catalogue he is indexing will go into a certain file. It can readily be seen that serially numbered publications do not follow in order in filing cases. When a case is filled a small letter "F" is put on the outside under the number. The odd sizes in which trade literature comes is a nuisance, but fortunately the large-sized publications, printed on extra heavy paper, seldom contain anything worthy of preservation. They seem to be generally gotten out to feed the pride of some one or other and make a job for a printer. Such expensive work is thrown away, except in so far as it tends to develop the art of printing and engraving. Few publications having pages exceeding 9 × 12 ins. contain data of any kind that is valuable. The small pocket sizes often are crammed with useful material.

The writer has seemingly laid stress on inexpensive methods. He does this because an engineer should start such work when he first opens his office. At that time he is not supposed to have much money to spare and he must needs practice economy. If he becomes successful later on and sighs for polished wood or metal covered filing cases they can be procured and the contents of the old files easily removed to the new ones. The cards can be removed from the cheap pasteboard boxes and put in the new handsome ones and no trouble will result.

The writer finds that such a system does all that can be expected of any good system and saves office space, which is quite an item where rents are high, and is so simple that any man can readily attend to it without having to keep track of too many threads.

INDEX MAPS FOR CITY WORK.—When an engineer is doing considerable work in one city and needs to refer often to benches and survey points, he can arrange in the following manner for keeping track of them. Procure a map of the city and divide it into spaces about 4½ × 7 ins., and give each space a number. Prepare cards of the same size, and on one side draw the part of the city in the space that card is intended to cover. Some engineers use a thin map by cutting it up and pasting the pieces on one side of the card. The map that is marked is the index and the cards are a record to take to the field.

When a bench is established, or a monument or a line point set, a record should be made on a card in a card index box, or it can be entered alphabetically by streets in a book. All points should be numbered, one set being used for survey points and another for benches. On the index map place the number in the proper location. On the small cards also put the numbers down in the proper location. Red ink is generally used for elevations and some other color for survey points. On the back of the card write the description and elevation. The cards are filed in a box in large envelopes, serially. When a survey is to be made in any part of the city a glance at the map on the wall gives the number of the card covering that part.

The card is removed from the filing case or envelope and placed in the back of the field book. This renders it unnecessary to do any copying when in a hurry. Having the information in a file in addition to the map card is a safeguard against serious danger if the map card is lost while in the field.

EVERYTHING IN ITS PLACE.—The writer is strongly opposed to roll-top desks, or desks containing more than one drawer, in an office. That is, in the office of an engineer having assistants. He prefers a flat top table, with one small shallow drawer, where the man using it can put pencils, etc., and where he can leave small things of his own at night. This table can have some shelves at one end on which to place things needed during the day, but everything should go to its place at night. A large metal cash box is convenient, and one can be placed on each table so that all books, memoranda, etc., used during the day can be locked in that box and be put away for the night. To keep the drawing boards and tables free from dust, and to protect papers tacked down, a linen or muslin cover should be hung over each every evening at quitting time.

Ernest McCullough.

P. O. Box 691, Chicago, Ill.

THE WABASH RIVER BRIDGE AT TERRE HAUTE, INDIANA.

By Malverd A. Howe,* M. Am. Soc. C. E.

A rather unusual combination of trusses and plate girders is presented in the new highway bridge constructed last year across the Wabash River at Terre Haute, Ind. This bridge replaces an old Burr truss wooden bridge, erected in 1864 by a private company and operated as a toll bridge until bought by Vigo County in 1874. The old bridge consisted of five truss spans, approximately 160 ft. each in length, and of a short draw span of the tipping type. The grade of the bridge was sensibly level, and the floor was about 5 ft. above maximum high water. The piers were composed of stratified limestone masonry, on a wooden grillage on piles. During its long service this masonry had become so badly weather checked that it had to be condemned. The tim-

FIG. 1. VIEW OF HIGHWAY BRIDGE OVER WABASH RIVER AT TERRE HAUTE, IND.

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ber in the old bridge, however, was remarkably well preserved, but brash, most of it being yellow poplar in the trusses, with a few main braces of oak.

GENERAL CONSIDERATIONS.—The west approach to the bridge is on a long fill crossing the river bottom lands, and is but a few feet above maximum high water. The east approach is a continuation of Wabash Ave., the principal business street of Terre Haute, and closely built up to within one block of the bridge. Within this block is a flour mill, with railway facilities along Water St., parallel with the river. For various reasons, the engineers were instructed to make as little modification of the grade in this block as possible; in fact, to so adjust the grade that there would be no damages to property holders. In respect to the bridge itself, the War Department required a clear headway of 10 ft. under a draw span, without requiring the installation of machinery for moving it. As the swing span in the railway bridge adjacent had never been opened for boats, it did not seem economical to put in machinery, even if less clearance could be had by so doing.

About four years ago the first designs were made and a deck bridge recommended. The designs were accepted, bids advertised for and opened. The bids ran above the estimates, and this was nominally the excuse for rejecting all of them. Two years ago another advertisement was made upon modified plans, which cut down the cost as much as possible by lowering the east approach and making six spans exactly alike. The lowest bid was accepted and work commenced in July, 1903.

GENERAL DESCRIPTION.—The new bridge is composed of six 120-ft. spans and one 75-ft. draw span in the center, at present without operating machinery. The roadway is 50 ft. in clear between curbs, and the two sidewalks are each 8 ft. in clear. The six 120-ft. spans are each composed of two riveted trusses, 53 ft. apart on centers, and three plate girders spaced equidistant between the trusses. The 75-ft. span has only the two truss girders. The roadway is about 14 ft. above the elevation of the old bridge floor and the bottom chords 38 ft. in clear above low water. From the center the roadway slopes away toward each end at a grade of 1.225%. Fig. 1 is a view of the completed bridge, and Fig. 2 is a half cross-section of one of the 120-ft. spans.

In explanation of the design, it should be noted that, considering the War Department requirement and the difficulty of making an easy grade from the west, it was necessary to keep the steel work within rather narrow limits. Plate girders were used under the floor on account of their durability, and the little field work required at essential connections. Trusses were used between the sidewalk and roadway to add to the general appearance of the bridge, and to provide a required barrier between the roadway and sidewalks of sufficient strength to make the walks perfectly safe. This will, perhaps, appear odd to many, but, considering the location of the bridge and the class of travel—made up of livestock, teams of all descriptions, electric cars; consisting, in fact, of everything which comes to the city from within a radius of 16 miles west—it will be seen that the plan is not as singular as appears at first thought. It may be noted that several designs were made, one of which left out all plate girders and used but two trusses, with floor beams like the 75-ft. span. This design was found uneconomical, and, besides, did not distribute the weight over the masonry as well as the present design does. With this explanation, the construction can be considered in more detail.

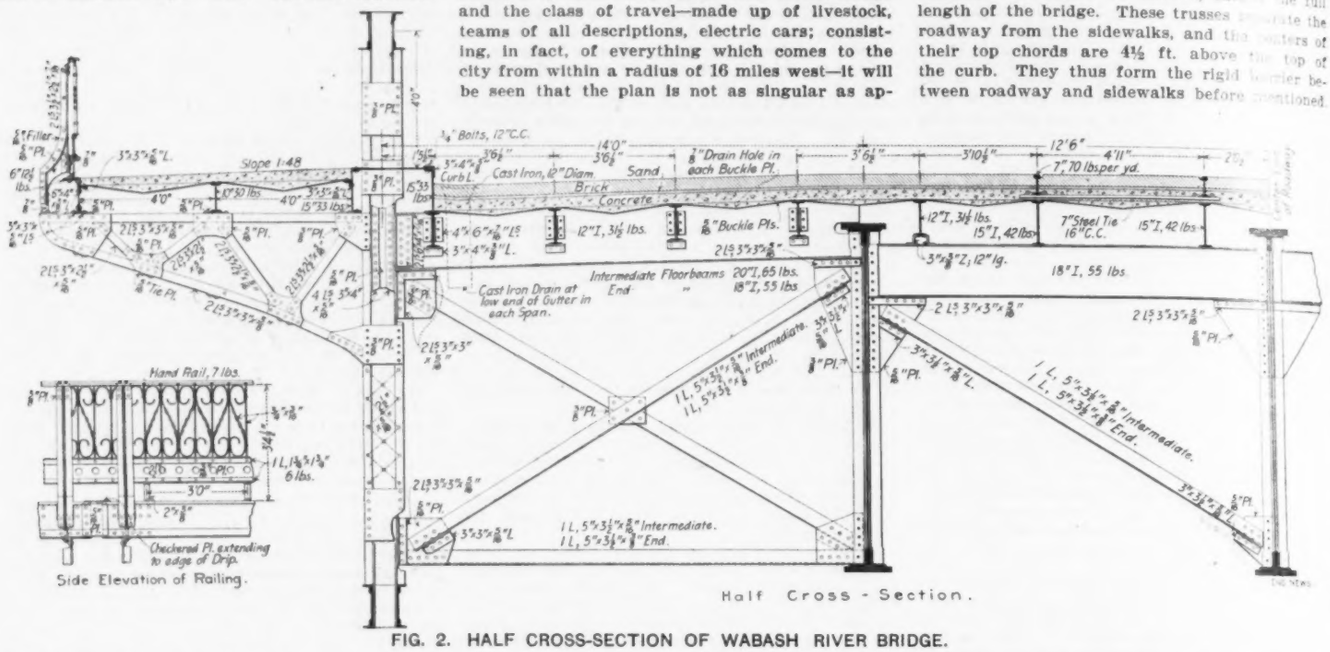


FIG. 2. HALF CROSS-SECTION OF WABASH RIVER BRIDGE.

SUBSTRUCTURE.—The substructure consists of two abutments and six piers, all composed of quarry-faced ashlar and concrete on pile foundations. The bottom of the concrete masonry is 9 ft. below low water in the piers, and extends to low water where the ashlar facing of Bedford limestone commences. This limestone facing is backed with concrete. Like the piers, the abutments are founded on piles, but the bottom of the masonry extends but 2 ft. below low water. The wing walls are not bonded to the abutments and rest directly on the soil. The old abutments were upon the soil at an elevation some 10 ft. higher than the bottom of the new masonry.

The total quantity of masonry in the piers and abutments is 6,230 cu. yds.; 718 piles of green hardwood were driven, 88 under each pier, 116 under the east abutment and 84 under the west abutment.

In the construction of the piers and the abutments the only point needing mention is the pile-driving. This was a slow process, as the piles drove hard in the sand and gravel bottom. A drop-hammer was used throughout the work. In the east abutment foundation a water-jet was successfully used until a penetration of about 16 ft. was reached, when it became useless. The driving was then continued with a hammer until a penetration of 20 ft. was reached.

TRUSSES.—As previously stated, two lines of trusses, 53 ft. apart on centers, extend the full length of the bridge. These trusses separate the roadway from the sidewalks, and the centers of their top chords are 4½ ft. above the top of the curb. They thus form the rigid barrier between roadway and sidewalks before mentioned. The outline and composition of the trusses are shown by the diagram (Fig 3), and also by Fig. 2. It will be seen that the trusses have the ordinary chord section for the top chord, built up channels for the bottom chord, rolled channels for the verticals, and four angles connected by a ¼-in. plate for the diagonals, the plate not being considered as part of the sectional area. Riveted trusses were used, on account of their stiffness. The bottom chord was curved, for sake of appearance, and was made of shapes for the same reason; the curved outline also gives the same headroom under the center of each span as is given by the plate girders. The expansion of the trusses is provided for by 8-in. segmental cast-steel rollers on T-rails, which extend under the fixed end bearing of the adjacent spans.

The foregoing description refers more particularly to the trusses for the 120-ft. spans. The trusses for the draw span were different, in having straight bottom chords and in having the end posts extend downward to form legs footing on the piers, with bracket braces to the bottom chords and end floor beams.

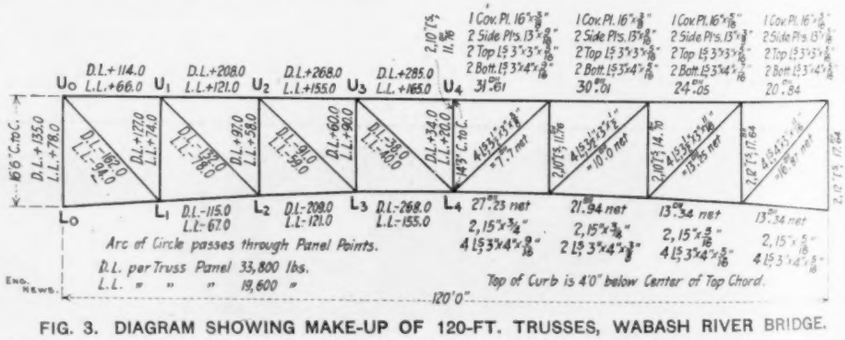

Arc of Circle passes through Panel Points.
D.L. per Truss Panel 33,800 lbs.
L.L. " " " 19,600 "
Top of Curb is 4'0" below Center of Top Chord.
120'0"

FIG. 3. DIAGRAM SHOWING MAKE-UP OF 120-FT. TRUSSES, WABASH RIVER BRIDGE.

PLATE GIRDERS.—As shown by the part cross-section (Fig. 2) of one of the 120-ft. spans, the space between trusses is occupied by three plate girders, each 121 ft. 6 ins. long. These girders are the longest used to date for a highway bridge, and were shipped in pairs on three cars. The general make-up of the girders is

shown by the diagram elevation Fig. 4, and Fig. 5 shows representative details. The weight of one girder was 60,500 lbs.

FLOOR SYSTEM AND SIDEWALKS.—The sidewalk and roadway floor are shown in Fig. 2. The sidewalks are supported by brackets riveted

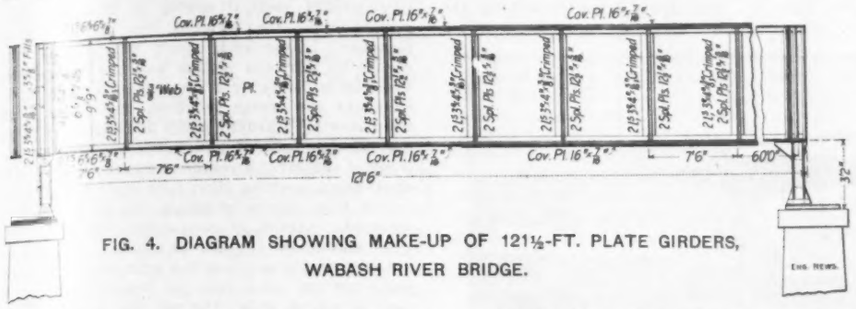


FIG. 4. DIAGRAM SHOWING MAKE-UP OF 121½-FT. PLATE GIRDERS, WABASH RIVER BRIDGE.

to the posts of the trusses; these brackets carry stringers, to which are riveted buckle plates covered with a cement finish. The roadway is paved with brick on a Portland cement concrete foundation supported by buckle plates riveted to stringers. Between the trusses and the adjacent plate girders the stringers are riveted between the floor beams, while between the plate girders they rest on top of the floor beams. Two lines of rails on steel ties traverse the roadway at the center for interurban cars. Among the details of special interest are the expansion joints in the roadway and sidewalks; these are shown in Fig. 6.

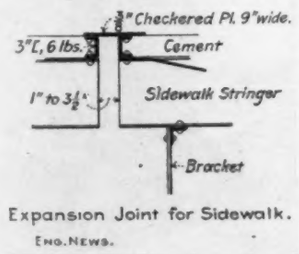
All wind and lateral vibrations are transmitted into the buckle plates by X-sway bracing. All sway bracing is riveted, and enough rivets used to make tight connections.

The cover or curb plate worked in around the truss members is riveted to the curb on the sidewalk side and bolted to the curb on the roadway side. As the posts were made of channels and the diagonals of four angles and a plate, the matching of the plates was comparatively straight work. The plates are continuous from the posts to the diagonals, making a very neat job.

The light and trolley poles were designed by the American Bridge Co. The contractor had the right to use any standard pole. This pole is very stiff and looks well. The hand-rail is an old Keystone design, modified in a few places.

Throughout the design particular pains were taken to make all parts accessible for painting, even to the top flanges of the plate girders. The sidewalk brackets were so designed that all portions could be painted and all rivets be free from tensile stress.

Although there are a number of details which perhaps appear very expensive, yet, when the number of pieces made from one templet is considered, they are not much more expensive than



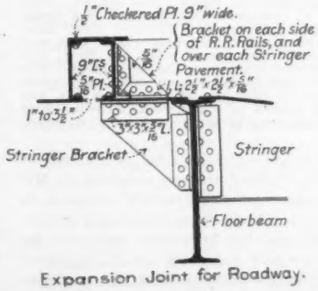


FIG. 6. DETAILS OF EXPANSION JOINTS IN ROADWAY AND SIDEWALKS, WABASH RIVER BRIDGE.

the ordinary straight-cut work. All field riveting was designed for hand-work. Practically all has been pneumatic work, thereby adding about 15% to the number of rivets this class of work would call for.

ERECTION.—The method of erection may be briefly described as follows: Falsework capable of carrying a single line of railway track was built between two of the 120-ft. plate girder positions. A single girder was loaded on two standard freight car trucks, and then, by means of tackles, moved out until the ends were over the masonry, where it was placed on blocking and moved sidewise until in its proper position. When the girders for a span were in position the floor beams, stringers and sway bracing were put in place and bolted up. The riveted trusses were assembled by placing the floor beams running from the trusses to the adjacent girders on top of the deck already formed and anchoring them down with the outer ends projecting beyond the girders about 2 ft. Then the truss verticals were bolted in place and the remaining members assembled and bolted. The outside rivets were driven, and then the truss and floor beams moved sidewise and lowered into their proper positions. One-half of the bridge was erected in this manner, and then the falsework for three spans was moved forward, the railway track being shifted to the lower flanges of the plate girders in place.

The only delay in traffic experienced was a few hours one Sunday afternoon, when the ice took out the temporary bridge, and a few hours on the following Monday required to complete a plank roadway on top of the buckle plates floor. Some of the trusses had not been riveted up when this occurred, but the joints were securely held in place with bolts and drift pins. Sixteen feet of the roadway was used for traffic while one-half was paved; then the traffic was turned onto the pavement and the remainder paved.

There were about 125,000 open holes to be filled with ¾-in. and ⅞-in. rivets. Of this number a comparatively few were filled with bolts. Curb angles and stringer shelf angle connections were bolted, and a few end floor beams, where it was impossible to drive rivets, were connected with turned bolts having a driving fit; nut and washer on each end. Practically all rivets were driven with pneumatic hammers and heated in oil furnaces.

The contractor for the entire work was The Lafayette Engineering Co., Mr. Wallace Marshall, President; Mr. Frank Hanna, General Manager at Terre Haute, and Mr. O. G. Wright, Superintendent of Erection. The steel work was fabricated at the Detroit branch of the American Bridge Co. The mill and shop inspection was done by the Pittsburgh Testing Laboratory. The writer and Mr. J. E. Starbuck were designing engineers and superintendents of construction for the Commissioners of Vigo county.

The contract price for the entire structure, including a temporary bridge, the removal of the old superstructure and substructure, etc., was $271,200, of which $192,500 may be considered as the cost of the new superstructure, the temporary bridge and the removal of the old bridge, and $78,700 the cost of the substructure and approaches.

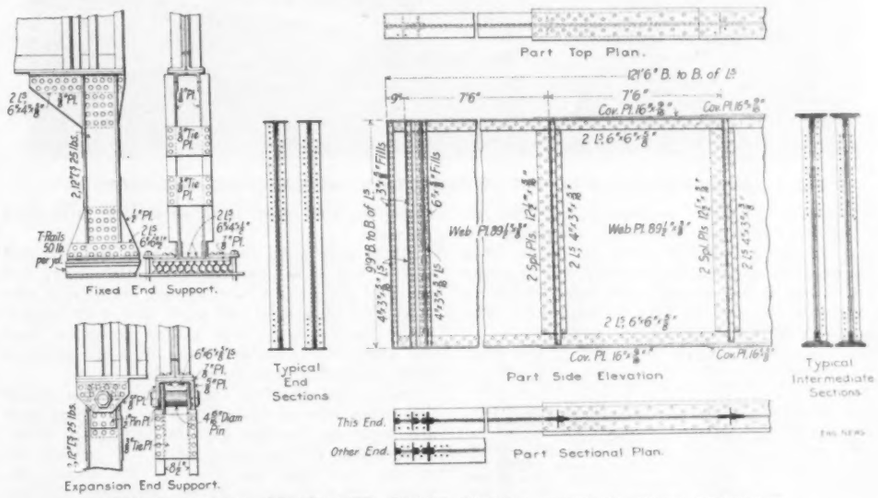


FIG. 5. DETAIL OF 121½-FT. PLATE GIRDER, WABASH RIVER BRIDGE.

THREE-CYLINDER COMPOUND LOCOMOTIVES ON THE GREAT CENTRAL RY. IN ENGLAND.

Three-cylinder compound locomotives have probably been tried more extensively in England than anywhere else, and engines of this class for fast passenger service are now being introduced experimentally on the Great Central Ry. of England. These have been built at the company's shops to the designs of Mr. J. G. Robinson, Mechanical Engineer. The engines are of the Atlantic (4-4-2) type, with one inside high-pressure cylinder driving the first axle and two outside low-pressure cylinders driving the second axle, the wheels being coupled in the usual way. According to a statement from Mr. Robinson, published in "The Engineer," the counter balances for the revolving and the reciprocating weights are divided to the best advantage in the coupled wheels. The high-pressure cylinder has a piston valve and the low-pressure cylinders have balanced slide valves, the valve arrangements being on the Smith system. We have commented upon these and other three-cylinder compounds in our editorial columns.

The Robinson engine is adapted to use high-pressure steam in the low-pressure cylinders

when starting. On the opening of the throttle, when working compound, live steam is admitted to the low-pressure cylinders through a reducing valve, which limits the pressure to 50 lbs. per sq. in. After the first exhaust from the high-pressure cylinder, the steam from the boiler is cut off by that from the high-pressure cylinder, and the reducing valve then closes. When working semi-

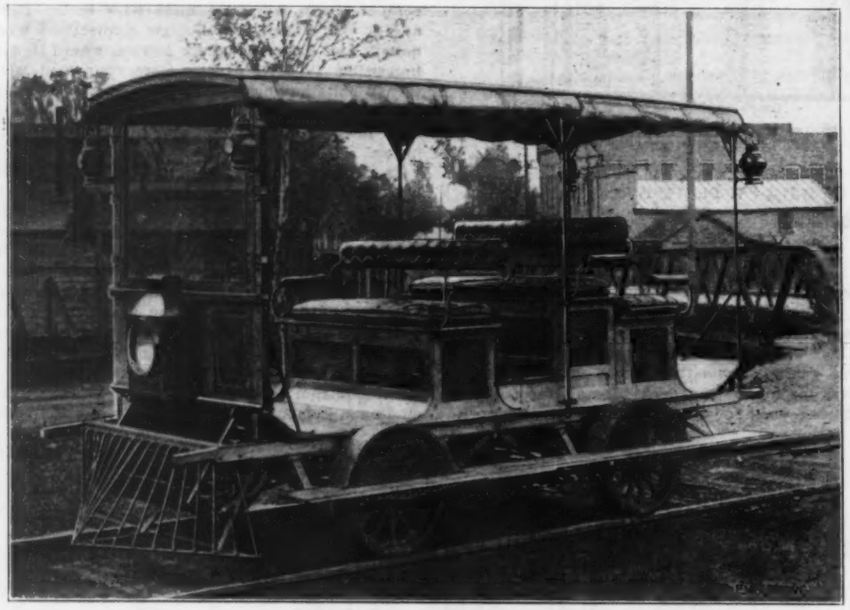


FIG. 1. SHEFFIELD RAILWAY MOTOR INSPECTION CAR, CARRYING NINE PERSONS.

compound, if the initial pressure is, say, 200 lbs. per sq. in., the engineman can compress the spring of the controlling valve by means of a hand-wheel in the cab, and in this way increase the pressure in the steam chest from 50 lbs. to as high as 150 lbs., as may be required. The dimensions of these engines are as follows:

Driving wheels (4) diameter	6 ft. 9 ins.
Truck wheels (4) "	3 " 6 "
Trailing wheels (2) "	4 " 3 "
Wheelbase, driving	7 " 3 "
Weight on drivers	82,880 lbs.
Weight on truck	38,080 "
Weight on trailing axle	38,080 "
Weight, total	159,040 "
Weight of tender (6 wheels)	94,080 "
Cylinders, HP. (1) inside	19 × 26 ins.
Cylinders, LP. (2) outside	21 × 26 ins.
Boiler, diameter	5 ft. 0 ins.
Working pressure	200 lbs.
Firebox (copper)	7 ft. 9⅛ × 3 ft. 4 ins.
Firebox, depth	6 ft. 7⅞ ins.
Tubes, No., 221; diameter (outside)	2 "
Tubes, length	15 ft. 4⅝ ins.
Heating surface, tubes	1,778 sq. ft.
Heating surface, total	1,931 " "
Grate area	26 " "
Water in tender tank	4,800 U. S. gallons.

MOTOR-DRIVEN INSPECTION CARS FOR RAILWAY SERVICE.

One of the notable innovations in railway service during the past few years has been the extensive introduction of light motor cars to facilitate track and general inspection work. These motor cars have to a very large extent superseded the inspection train composed of engine and car (or caboose), with its crew, the inspection locomotive (fitted with special observation cab), and also the hand-car on which the official was "pumped" over the road by men taken from the section gang.

With the motor car a trip can be made at almost any time by from one to eight or nine persons. Good speed can be maintained and stops can be made at any point, the car being taken off the track if a long stop is to be made. In this way the engineer, roadmaster or other official can readily arrange for a general trip of inspection or for a visit to any work in progress on the road without interfering with the operating department and without incurring the delay and expense incident to the use of a special train and crew. Many roadmasters, bridge and signal engineers, etc., now use light motor cars instead of hand cars, and by thus getting over the road more rapidly they are enabled to give more time to their regular work. The hand cars of section gangs, bridge and signal repair gangs, etc., are also in many cases being replaced by motor cars, which not only save time by taking the men more rapidly to and from their work, but also relieve them from the exhausting labor of driving the car. These cars are also used to some extent for inspection and repair work on electric interurban railways.

Steam cars have been used to a very limited extent, but were not generally satisfactory, and gasoline motors are now almost exclusively employed for inspection and work cars of all classes. They require much less skilled attention than the steam cars, besides being in other respects more convenient and economical.

One of the Sheffield Car Co.'s gasoline motor inspection cars is shown in Fig. 1. These cars are built in various designs and with either longitudinal or transverse seats. A car similar to this was used last year by Mr. George H. Webb, Chief Engineer of the Michigan Central Ry., for a trip over the system, and the following particulars of the trip have been furnished to us by Fairbanks, Morse & Co., of Chicago, who are the agents for the Sheffield cars:

The total distance traveled by the car was 4,347 miles, and the total amount of gasoline used was 231 gallons, or an average of 19.7 miles per gallon of gasoline. The records show that on the run from Jackson, [illegible]ch to Allegan and return, a distance of 140 miles for the round trip, only 7½ gallons of gasoline were used, or 23.3 miles per gallon. The total cost per mile, including lubricating oil, battery cells and everything excepting wages of man in charge was 0.9 ct. This is a large saving as compared with the cost of a steam locomotive pulling a private car. The run from Marshall to Allegan, 66.4 miles, was made in 1 hour and 40 minutes, or at the rate of 40 miles per hour, and it is reported that the engine was never stopped. The distance from Tekonsha to Harris, 29 miles, was made in 45 minutes and the best run of the entire trip was made from South Haven to Kalamazoo, a distance of 39.6 miles, in 45 minutes, or at the rate of 52.94 miles per hour.

The need of precaution in the operation of these cars is evident, and we are indebted to Mr. Webb for particulars of the practice followed in the operation of his inspection car noted above. This car is used only for inspection purposes by the Chief Engineer and Assistant Chief Engineer. One of the conductors accompanies the engineer and operates the car. He has a good knowledge of its mechanism, and is capable of making such light running repairs as may be needed from time to time. Although last season the car was not so equipped that it would set the automatic signals, it is now being altered so that it will set the block signals, and thus be protected from the rear. This car is operated under train orders, the conductor getting his orders from the dispatcher in the usual way. Particular attention is paid to order boards at telegraph offices to see whether they are set against the [illegible] or not. Of course, when there are no special [illegible]fers the car is expected to make meeting [illegible]s with regular scheduled trains, the same as [illegible] train running extra.

In the Sheffield cars of this type the [illegible]or is a two-cylinder vertical engine of 12 [illegible]5 HP., placed under the forward seat and [illegible]ing a planetary transmission gear, which [illegible]s two speeds for forward motion and one [illegible] reverse. The axle is driven by a sprocket-chain [illegible]r. The cylinders are water jacketed, the w[illegible] being circulated by a geared pump and cool[illegible] by passing through coils of automobile radiat[illegible] pipe in front of the car. A compression oiler [illegible]s generally used, but a positive oiler, with sight-f[illegible] glasses on the front of the vestibule, can be [illegible]d when required. A pilot or cowcatcher, side [illegible]ps and other auxiliaries can also be applied. The standard fuel supply is a 5-gallon tank under the front seat, but for long runs an auxiliary 25-gallon tank is placed under the car, the gasoline from this being forced into the smaller working tank by compressed air. These cars weigh about 1,650 lbs., and can carry nine or ten people. A special turning jack can be used to raise and slew the car when taking it on or off the track, but six men can handle it without the aid of this device. A lighter inspection car, with 22-in. wheels and two transverse seats (for four persons), has a single-cylinder vertical engine of 6 or 7 HP., and weighs 1,100 lbs. The section tool cars have the same engine equipment and weight, but can carry a gang of 8 or 9 men with their tools. These have no canopy.

An Olds gasoline motor inspection car of a somewhat different pattern is shown in Fig. 2. It weighs about 800 lbs., and is driven by a horizontal four-cycle engine of 4½ to 6 HP., having a single cylinder 4½ × 6 ins. These cars are handled by the Railway Appliances Co., Chicago, which states that they are operated on grades up to 7½%, and that the fuel consumption under ordinary conditions will be about 1 gallon of gasoline per 15 miles run. In demonstrating one of these cars on the Atchison, Topeka & Santa Fe Ry., less than 4 gallons were used in a run of 83 miles.

Both the Sheffield and Olds cars are being employed for distributing newspapers. The Dayton "Journal" recently instituted a service of this kind between Dayton and Springfield, O., on the Dayton, Springfield & Urbana Electric Ry. An ordinary Olds inspection car is used, fitted with canopy or hood, glass front, etc. It makes the run in one hour, and delivers the papers in about twenty villages and towns from one to three

Fig. 2. Olds Single-Cylinder Railway Motor Inspection Car.

Railway Appliances Co., Chicago.

hours earlier than by the first regular morning car.

A still lighter inspection car, weighing but 500 lbs., and seating three or four persons, is built by the Light Inspection Car Co., of Hagerstown, Ind. This has a 3½-HP. gasoline engine with a single air-cooled cylinder, 4 × 4 ins., and running at 1,200 to 1,500 revolutions per minute. The axle is driven by a block chain, and the speed of the

car is controlled by a foot lever or treadle which regulates the air supply to the mixing chamber of the cylinder. These cars have 17-in. wheels with wood centers and steel tires. The transmission gear gives two forward speeds (20 to 25 miles per hour for running and 7 miles an hour for starting or climbing grades), and one reverse speed. The changes are made without affecting the engine. The fuel tank carries 3½ gallons of gasoline, which the makers state to be sufficient for a run of 100 miles.

A NEW DESIGN OF PNEUMATIC PLUG DRILL.

Several styles of pneumatic plug drills for quarry work, etc., are in use, and a new drill of this class which presents some special features of design is now being introduced. One of the principal features is the elimination of the trigger mechanism for operating the throttle valve. The handle is fitted telescopically to the barrel, and

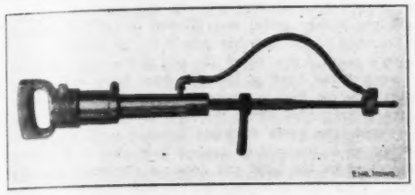


Fig. 1. A New Style of Pneumatic Plug Drill.
The Sullivan Machinery Co., Chicago, Makers.

when pushed down by the operator in throwing his weight against it the movement of the handle shifts the cylindrical throttle valve so as to open the port and admit the air to the working barrel. When the handle is released the pressure of the air returns the valve to its closed position. The advantages of this arrangement are twofold. In the first place, the mechanism and working parts are reduced to a minimum, and there are no small parts liable to get out of order; in the second place, the machine can be operated with greater comfort and facility in winter, since the operator (having simply to grasp the handle) can wear the usual working mitts and handle the machine as readily as a pick or shovel. The valve, valve block, drill shank bushings and cylinder are of hardened tool steel, and all parts are made interchangeable. A solid steel drill is used, and is rotated by a hand wrench fitted to the square section of the drill. On the drill slides is a collar carrying the end of a blower hose attached to one of the exhaust openings, the exhaust being thus discharged into the hole and blowing out the dust and dirt. Air at 80 to 100 lbs. pressure is used with these drills, and they will make holes up to 12 ins. in depth.

In a test made for one hour at the Innes & Cruickshank granite quarry, at Barre, Vt., one of these machines drilled 160 plug holes, ⅝-in. diameter and 3 ins. deep; both horizontal and vertical holes were drilled, and the machine was operated by one of the regular quarrymen. The air pressure was 100 lbs. per. sq. in., and the machine used 14 cu. ft. of free air per minute. It is stated that this is the highest record ever made in this class of work, the previous record being only 60 holes per hour at about the same size. This new drill is manufactured by the Sullivan Machinery Co., Railway Exchange Building, Chicago, and we are indebted to that company for photographs and other information.

WATER WASTE RESTRICTION AND FILTRATION PLAN CHANGES RECOMMENDED FOR PHILADELPHIA.

A report on the completion of the Philadelphia filtration system and on much-needed immediate steps for the suppression of water waste in Philadelphia has been made by Major Cassius E. Gillette and John D. Maclennan, M. Am. Soc. C. E., two of the three experts appointed last summer to investigate the Philadelphia filtration contracts and related matters. The report in full may be found in the Philadelphia Ledger for March 2, and probably in other Philadelphia papers of the same date. Owing to press of other work Mr. Wm. Barclay Parsons, M. Am. Soc. C. E., did not join in the report.

Starting with the great discrepancy between pumping records and the volume of water which passes the filters supplied by the corresponding pumps during the year 1905, Messrs. Gillette and Maclennan review the pump slip at all the pumping stations in the city. They find that, as against a total of 327,351,000 gallons pumpage reported by the Water Bureau, there is a slip of 82,399,000 gallons. The slip for the various pumps ranged from 8 to 56%, and averaged slightly over 25%. Besides the lack of economy shown by these pumps, the tests indicate that many of the pumps are likely to fail at any time. On a basis of 10% allowable slip, there would still be 49,000,000 gallons a day slippage which might be prevented. This, at $5 per million gallons, amounts to $89,425 a year, or the interest on $2,235,625.

The average daily per capita consumption, instead of being 233 gallons as reported by the Water Bureau, is really 164 gallons, and "of this more than one-half is wasted." This is shown by the fact that the night consumption, from 1 to 5 a. m., is at the rate of 79% of the average daily rate. If the consumption were cut to 100 gallons per capita per day, it would be possible to dispense with extensions to the works, now considered necessary, at a total cost of $4,288,000, and also to dispense with useless pumpage at a yearly charge of $233,380, which, capitalized at 3½%, equals $6,382,286, making a "total of $10,670,276, literally to be thrown into the sewers of Philadelphia as wasted water that has benefited no one."

The bad condition of the pumping machinery, while partly due to incompetent operation, "is also largely due to its being overworked in a struggle to pump a vast quantity of water into the city reservoirs in order that half of it may run uselessly into the sewers."

The remedy is, a meter on every consumer. This would require about 300,000 meters, at an average cost of $16 each. It is suggested that these should be supplied by the city but paid for by the consumers in small instalments. The saving in water to consumers which would result would pay for the meters in a short time. The experts ask, "Why pay $20,000,000 for a filter plant and then find by metering that a $10,000,000 plant would have done just as well?"

A considerable part of the report is taken up with a discussion of the wisdom of the changes that have been made in the original plans for a filtration plant, as recommended by the Hering-Wilson-Gray Commission (see Engineering News Oct. 5, 1899). Several of these changes, which are chiefly of local interest, are condemned, especially so extensive an abandonment of the Schuylkill River as a source of supply as has been made, the substitution of the Torresdale Tunnel conduit for pipe lines, and the abandonment of the existing Queen Lane pumping station and reservoir, and the omission of the proposed filter plant at this reservoir. As to the quality of the water in the Delaware River at Torresdale, the bacterial records up to a year ago showed the water to be better than that from the Schyulkill, but for the year 1905 the Delaware water was shown to be worse, and the experts believe that in the future there will be still further deterioration in the quality of the Delaware.

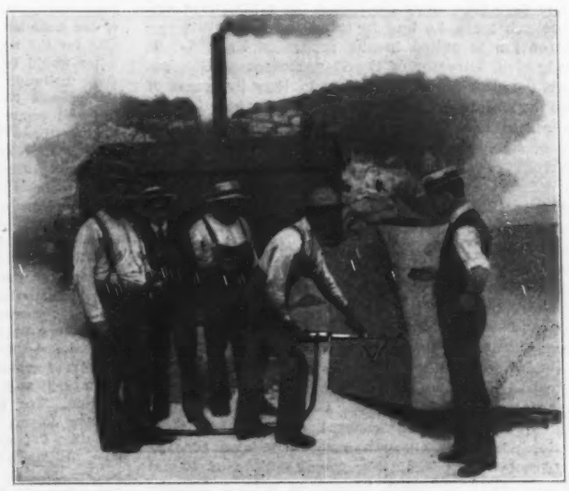


FIG. 2. PNEUMATIC PLUG DRILL IN USE AT A GRANITE QUARRY.

In view of the statements just made, the experts believe that in the future the Torresdale should be supplied by gravity from some 40 miles up the Delaware River, at Point Pleasant. This might be effected by means of an open canal, since the water is to be filtered in any case. Such a plan would eliminate the low lift pumping plant at the filters, and would also give a less difficult water to purify. The present Torresdale pumping station should be completed, however, and that in a substantial way, but with no attempt at securing high duties.

The experts recommend the cancellation of all filtration contracts now held in the name of D. J. McNichol & Co. The final recommendations of the experts are to let contracts at once for all portions of the filter works and accessories needed to bring the partially completed plant into use; to begin the construction of a filtration plant at the Queen Lane reservoir, as recommended in 1899; and to "provide for metering every consumer's pipe, including city buildings, and others that do not pay water rates, so that the record of the meters will check the record of the pumps."

The Torresdale pumps should be four or six in number, of 40,000,000 gallons capacity each, evidently of the centrifugal type. The actual number of pumps to be installed will depend upon the action taken on the recommendations for metering, "which action should be taken immediately."

It is understood that Mayor Weaver approves of all the recommendations made in the report.

NOTES FROM THE ENGINEERING SCHOOLS.

NEW YORK UNIVERSITY.—Announcement of evening courses for young men employed in the railroad offices of New York City has been made by Dean Johnson, of the School of Commerce. So far as practicable, the instruction will be given "by experienced railroad men, and will deal with concrete facts and conditions." For the half-year beginning Feb. 5 the course will include railroad accounting, under Controller Blauvelt, of the Erie Railroad, and C. E. Forsdick, of Haskins & Sells, public accountants, New York City; railroad law, under Robert Walker, Assistant to the General Counsel of the Rock Island System; rate-making and rate problems, W. H. Lough, Jr.; railroad finance, T. W. Mitchell; industrial geography, W. C. Webster.

POPLAR (London) SCHOOL OF MARINE ENGINEERING.—This school was formally opened the latter part of January, 1906, but has been receiving students since September, 1905. The school was provided by the London County Council at a cost of about $125,000, of which four-fifths was for building and one-fifth for equipment. The building was erected by the Works Department of the London County Council. The site for the building has an area of 11,764 sq. ft. The building consists of three floors and a basement. In the basement are located the boiler and engine rooms, marine and electrical engineering laboratories; above are laboratories, lecture and class rooms, drafting rooms, pattern makers' shop and other departments. Further information on the school and its relation to the ship-building industry and the "working classes" may be found in London

"Engineering" for Jan. 26, 1906, from which the above notes have been taken.

COLUMBIA UNIVERSITY.—A plan for an athletic field and a water gate, the latter to serve as a formal entrance to the University grounds, has just been made public. The plan involves filling in the Hudson River front to the bulkhead line, between 116th and 120th Sts., and building piers from the bulkhead to the pierhead line, with the proposed water gate at the center of the pierhead. The athletic field and accessories would be available for general use, it is said, when not needed for Columbia events. The plan is said to have originated with Mr. Daniel LeRoy Dresser, of the class of 1889, and to have been elaborated by a committee which included Mr. Wm. Barclay Parsons, M. Am. Soc. C. E., of the class of 1879. The designs thus far made are credited to Henry F. Hornbostel, of the class of 1891, an architect, with offices at 63 William St., New York City. The estimated cost of the project is slightly more than $1,000,000, of which about $400,000 would be required for filling in the river front. In general line with the improvement just outlined is one proposed by Mr. John A. Bensel, M. Am. Soc. C. E., Commissioner of Docks and Ferries for New York City, involving the reclamation of the whole Hudson River front from 72d to 130th St. Both plans were scheduled for presentation to the New York Sinking Fund Commission on Feb. 7.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.—The report of President Henry S. Pritchett, dated January, 1906, contains a review of the proposed alliance between the Institute and Harvard University, and a discussion of the future course to be pursued by the Institute, now that the alliance has been given up. The final conclusion in the matter of the proposed alliance was the result of the decision of the Massachusetts Supreme Court on Sept. 6, 1905, which "denied to the Institute any right of this property [Boylston Street land] in fee simple, and specifically enjoined it from either selling or building over the two-thirds area not now occupied." The decision also makes it necessary, regardless of the proposed alliance, to continue the occupancy of the Boylston Street site for at least twenty or twenty-five years to come. It is therefore proposed to acquire more land near the present engineering buildings, to secure money sufficient "to make this site the seat of an effective and well-equipped group of engineering buildings," and to build students' dormitories on the "Brookline site, adjoining the Athletic Field." It is also suggested that both undergraduate and research work be had in mind for the future.—— Attention is called in the report of Prof. W. T. Sedgwick, Director of the Department of Biology, to a demand for graduates in biology in excess of the available supply. Students in this department, in the face of the increased demand for graduates, have fallen off in numbers with the current year. Professor Sedgwick states that it is difficult to persuade entering students or their parents "that biology is a really practical subject," although later on students in other courses say that if they had understood at the outset "what the course in biology is and what it leads to, they would have elected it without hesitation." A short optional course on the hygiene of heating and ventilation for fourth-year students in mechanical engineering "is steadily growing in attendance, and is of somewhat exceptional interest and value." At the Sanitary Research Laboratory and Sewage Experiment Station, which is under the general direction of Professor Sedgwick, there has recently been erected a trickling or percolating sewage filter of 10,000 gallons daily capacity, "equipped with a distributing device of original design." Two years of sewage experiments were completed in July, 1905. A digest of this work is being prepared by Messrs. Winslow and Phelps, of the Research Laboratory, and to this digest there will be prefixed "a comprehensive review of the present state of the sewage disposal problem in England, Germany and the United States." Among the various appendixes to the report it is interesting to note that there is one summarizing by classes cases of illness during the school year, and also another consisting of a report of the medical adviser. The latter official gave three talks on personal hygiene during the year to the first-year class.

PLANS FOR BARGE CANAL WORK aggregating $6,000,000 in cost have been passed upon by the Board of Advisory Engineers. The plans will now go to the New York State Canal Board for consideration. The work includes three dams and three locks on the Mohawk River between Schenectady and Amsterdam, two locks and two dams in Fulton and Oswego counties, and 12 miles of enlarged canal between the foot of Oneida Lake at Brewerton and Three River Point, along the Oneida River. The three dams proposed on the Mohawk are of a new type of movable dam, which has never been used in this country before.

A HIGH DAM ACROSS THE COLORADO RIVER, an electric power plant, and a transmission line to Los Angeles, Cal., are talked of by Los Angeles and Philadelphia capitalists. It is said that a concrete dam 200 ft. high will be built at the lower end of a canyon and 110,000 HP. developed. At the start, power would be supplied to mining camps at Searchlight, Bullfrog and Tonopah, Nev., and Gold Roads and Chloride, Ariz. Later, power would be transmitted to Los Angeles, a distance of more than 200 miles.

THE KLAMATH IRRIGATION PROJECT, Washington, being carried out by the U. S. Reclamation Service, is to be hastened at the request of the Klamath Water Users' Association. The original agreement between the government and land owners provided that this project should be prosecuted slowly, to allow large land owners plenty of time to close out their land holdings, in excess of the government minimum, and to prevent over-production of crops in this district, which is far from market. It appears that there is no longer reason for delaying the work, for the reasons just stated, nor do the engineering difficulties make delay necessary. No large contracts will be let, however, until the railway now under construction reaches Klamath Falls, as the cost of the irrigation works will be greatly lessened as soon as the long wagon haul is done away with.

A NEW YORK METROPOLITAN SEWERAGE COMmission is provided for by a legislative bill prepared by the New York Bay Pollution Commission. The bill accords with the general recommendations of the last-named commission, as made in the report submitted by it last spring and abstracted and commented on in our issue of May 4, 1905. It provides for a temporary New York commission, consisting of five citizens appointed by the Governor, and in addition the Engineer and Attorney-General of the State and the Mayor of New York City. Two of the appointed commissioners must be residents of New York City and one at least should be a lawyer and two at least should be engineers. The members of the commission would receive expenses and a per diem allowance, to be fixed by the Governor, for time "actually and necessarily employed on the work of the commission." The sum of $15,000 would be available for the work of the commission. The duties of the latter would be: (1) To continue the studies of bay and river pollution in the metropolitan district, begun by the present New York Bay Pollution, whose extended life will expire on April 30, 1906, and particularly (2) to investigate present conditions and future needs of sewage disposal in the whole district; (3) to cooperate with any authorized New Jersey commission in an exhaustive investigation of means to prevent the pollution of the waters of the district, by pumping sewage to sea or otherwise, said investigation to give particular attention to the best administrative plan for constructing and operating disposal works, either by separate commission for the territory in each state or by an interstate commission, agreed upon by each state, and ratified, if necessary, by the United States; (4) to submit to the New York legislature a full report, with plans and estimates, by Feb. 1, 1909, on the "several plans deemed worthy of especial consideration," and also definite conclusions, if any, reached jointly with a New Jersey commission. The bill provides for inviting the cooperation of New Jersey. The membership of the New York Bay Pollution Commission is as follows: Daniel Lewis, Chairman, 616 Madison Ave., New York City; Louis L. Tribus, M. Am. Soc. C. E., Secretary, 84 Warren St., New York City; Prof. O. H. Landreth, Schenectady, N. Y.; Myron S. Falk, Jun. M. Am. Soc. C. E., and Geo. A Soper, Assoc. M. Am. Soc. C. E., both of New York City. Copies of the bill may be obtained by addressing the secretary, as above. Dr. Lewis was formerly health commissioner of New York State.

THE LAKE ERIE & OHIO RIVER SHIP CANAL project has been revived and a bill to incorporate a company for its construction has passed the House of Representatives. The proposed canal would be about 100 miles long, from Ashtabula on Lake Erie to the Ohio River, following the valleys of the Mahoning and Beaver Rivers. The summit level would be 327 ft. above Lake Erie, and 321 ft. above the Ohio River. There would be 33 locks, each 345 ft. × 45 ft. × 12 ft., with ... lift. The cost of construction is estimated at $40,000,000.

AN ELEVATED RAILWAY FOR CHICAGO, ... bring electric interurban cars into the center of the city is proposed by the Chicago Elevated Interurban Terminal Traction Co., in which representatives of the ... Chicago, Rock Island & Pacific Ry. are said to be interested. The plan, as reported, is to build the elevated structure over the right-of-way of the Chicago, Rock Island & Pacific Ry., from Washington Heights to the La Salle St. station, an upper deck being built in the train-shed. The distance is about 10 miles, and south of Washington Heights the tracks would be laid on the surface and extended to connect with the various interurban systems now in operation and projected through Illinois, Indiana and Michigan. Eventually, electric connection with St. Louis and Indianapolis is expected to be completed. The cost is estimated at $6,000,000.

CAST-WELDED AND GROUND RAIL JOINTS are being used in improving the tracks of the Calumet Electric Street Ry., of Chicago. In the first part of the work the molten metal was allowed to reach almost up to the head of the rail, but now it is not allowed to rise above a point 2 ins. below the top of the rail. In order to prevent the head of the rail from being softened or injured by too high a temperature, a sheet iron pan of water is suspended above the joint as soon as the metal is poured, the water trickling through perforations and flowing upon the rail at such a rate that it is mainly evaporated on the head and does not run down upon the joint. With this arrangement, the rail head is never so hot that it cannot be touched with the bare hand. The work is done in sections, as required, and about 2000 joints of 6-in. and 7-in. girder rails have been welded. About 40 joints are done at a time, the portable cupola being set at the middle of the section and the work being done in both directions. The joints have previously been cleaned by the sand blast, and 40 joints are sometimes cast in an hour. After the molds and clamps have been removed, the joints are finished by emery-wheel grinders mounted on a shaft in a self-propelling truck, on which the operator rides.

TEST BORINGS IN THE HUDSON RIVER BED are to be made by the Board of Water Supply of the City of New York. A contract for this purpose was let recently to the American Diamond Rock Drilling Co., 95 Liberty St., New York City.

THE YUMA IRRIGATION PROJECT IN ARIZONA and California involves not only the construction of a large dam without rock foundations across the Colorado River above Yuma, Ariz., but also a pressure pipe to conduct the waters of the main canal beneath the valley of the Gila River, and also levees to confine the stream to a definite channel before the pipe crossing is constructed. It is proposed to build the dikes during the coming spring and summer and the pipe crossing during next winter. The dikes are made necessary by the sudden change of the river channel. Such changes, necessitating resurveys, have occurred twice since this project was initiated. Owing to the urgency of the work, the Secretary of the Interior, on recommendation of the Board of Consulting Engineers, has ordered the levees to be undertaken immediately by the United States Reclamation Service "by force account." The Laguna dam was described and illustrated in our issue of Feb 9, 1905. It will be 4,750 ft. long, 19 ft. high, will have a maximum width of 285 ft., and will contain 350,000 cu. yds. of loose rock. It will form a reservoir a mile wide and 10 miles long. To limit as much as possible the amount of silt drawn into the canal from the waters of the Colorado, the headgates of the Laguna dam will be arranged to draw off only the top foot of water. The contractors for the dam are J. G. White & Co., New York City.

A PORTION OF THE SHOSHONE INDIAN RESERvation, some 2,000 square miles in area, is to be thrown open for settlement during the coming summer. The land lies in Fremont and Bighorn Cos., Wyo., north of Wind River and east of the Popo Agie and Bighorn rivers. The rainfall here is only some 13 ins. per annum, but considerable bottom land areas could be irrigated by small ditches. Gold and other ores occur in the granite and associated schists of the Owl Creek Mts., possibly in paying quantities. The U. S. Geological Survey will soon issue a report on the geological features of a part of the area described.

THE PENNSYLVANIA RAILROAD PENSION DEpartment, during the six years of its existence ending Dec. 31, 1905, has authorized the payment of $2,904,088 pension allowances to retired employees. This does not include the operating expenses of the department, which are met by the company. During the six years application of the pension plan, 2,700 employees have been re-

tired as pensioners from the active service of the company, of which number 890 have died. Of the total number retired, 688 were between the ages of 65 and 69 years, of whom 546 were retired on their own request with the approval of the employing officer.

A TORNADO KILLED TWENTY in destroying part of the city of Meridian, Miss., on Friday, March 2. The storm occurred about 6 p. m. and passed with great rapidity through the city, going approximately from southwest to northeast. A large amount of property was destroyed, including hotels, stores and factories; the principal residential sections were not touched. The dead are at least twenty, probably twenty-five or thirty, and many more were injured.

A GREAT STORM which produced vast loss of life is reported from Tahiti Island, one of the Society Islands. The reports are very vague as yet. The islands have in the past repeatedly suffered from flood waves caused by storms; their low elevation makes them specially subject to damage of this nature.

THE PRELIMINARY WATER FILTERS under construction or proposed at Philadelphia are alleged to be infringements on U. S. Patents Nos. 800,107 and 800,108, applied for on Nov. 8, 1904, and Feb. 13, 1905, by Mr. John W. Hill, M. Am. Soc. C. E., and granted to him on Sept. 19, 1905. The allegation was contained in a letter addressed to Mayor Weaver during the latter part of February, 1906, by Mr. Edward Ritchie, of Cincinnati, "in behalf of the present owners" of the patents. Inquiry made for Mayor Weaver brought out this information from Mr. Ritchie:

Certain clients of mine, knowing through me of Mr. Hill, are organizing a company, with ample capital to instal filtration plants throughout the country under patents taken out by Mr. Hill in last September.

It developed in conversation that the city of Philadelphia is either now building or about to build preliminary filters, which I think clearly infringe these patents. I do not think, in view of the fact that Mr. Hill was not allowed to complete the installation of the plant originally designed and intended by him to be completed, that the work thus far done by Mr. Hill in Philadelphia amounts to a license to construct under these patents.

The city of Philadelphia has been notified by Mr. Ritchie that unless "satisfactory arrangements" are made with the owners of the patents or work on the preliminary filters is abandoned he will "proceed against the city to enforce" the rights of his clients. Mr. Ritchie is also reported as saying that Mr. Hill is not a member of the Filter Construction & Operating Co., but will be employed by the company.

ECONOMICAL PUMPING is performed by a 70-HP. Mietz & Weiss oil-engine pumping unit, according to figures furnished us by the builder, A. Mietz & Co., 128 Mott St., New York City. The engine is a double cylinder oil engine of regular Mietz & Weiss type, running at 250 r. p. m. Direct-coupled with it is a centrifugal pump, which in one specific instance was of capacity 3,500 gallons per min. against 45-ft. head, at 250 r. p. m., operating at 70% efficiency. This pump had a 15-in. suction and a 12-in. discharge pipe; its maximum capacity was 5,000 gallons per min. The engine is stated to consume 0.84 lb. fuel oil per brake horse-power-hour. With the pump efficiency of 70% this would equal a consumption of 1.20 lbs. oil per water horse-power-hour. A considerable number of pumping units of this type and size has been furnished recently for irrigation, the buyers being American, European and Javanese.

HYDROGRAPHIC WORK IN COLORADO and vicinity is to be facilitated by the U. S. Geological Survey, by restricting the area under the supervision of the Denver office. This office is in charge of Mr. M. C. Hinderlider, who will hereafter have charge of work in Colorado, Nebraska, Kansas and a part of Wyoming, thus cutting off South Dakota, Indian Territory and parts of Oklahoma and New Mexico. The possibilities of power development in Colorado are considered great, in view of the fact that there are located in that state the headwaters of the Arkansas, Rio Grande, North and South Platte rivers, and a large part of the Colorado, which latter is formed by the junction of the Grand and Green rivers. In addition, of course, it will be understood that the importance of these streams to irrigation is great.

DAMAGES FOR STREAM POLLUTION by smelting companies in the vicinity of Butte, Mont., have been under investigation by Oliver T. Crane, Master in Chancery of a United States Court, in a suit brought by Mr. Hugh Magone. Damages to the amount of $20,000 were asked and also an injunction to prevent the discharge by smelters at Butte of chemicals and tailings into creeks and Deer Lodge River. The Master finds damages to the amount of $1,500 in favor of Mr. Magone, and these he apportions among the Anaconda Copper Co., Butte & Boston Mining Co., and other defendants. Many figures regarding the number of men employed, salaries and taxes paid, etc., are cited by the Master to show why an injunction should not be granted.

A UNIVERSAL HYGIENIC EXPOSITION AT VIENNA, Austria, will be opened on May 12, 1906, and will continue until July 15. There will be ten groups of exhibits, as follows: House and residence hygiene; health and sickness; public hygiene; prevention of accidents and rescue work; chemistry and pharmacy; food and drink industry; clothing industry; tourists and travel; sport and games; literature and graphic industry. Exhibits will be received between April 15 and May 10, but an extra charge of 15 per cent. will be made for space of all exhibits, applications for which are filed after March 1. The exhibits should be addressed as follows: "An die Direktion der Allgemeinen Hygienischen Ausstellung, 1906, in Wien Rotunde." In order to secure the benefit of reduced freight charges at the end of the exposition every bill of lading should be marked "Ausstellungsgut." It is expected that all foreign exhibits, excepting food products, will be admitted free of duty.

RIVER FRONT IMPROVEMENTS at Albany, N. Y., are proposed if the necessary legislation can be secured. The improvements include a new concrete dock wall from end to end of the city, an intercepting sewer and a recreation pier. The latter would be similar in many respects to the recreation piers which have given such satisfactory results in New York City.

PERSONALS.

Mr. David Trainer has been elected President and General Manager of the Alma Cement Co., of Wellston, O., succeeding Mr. B. D. Lathbury.

Mr. E. G. Holiday has been appointed Chief Engineer of the Nashville Terminal Company, with office at Nashville, Tenn., to succeed Mr. L. F. Lonnbladh.

Mr. Harry R. Hall has been appointed Superintendent of the Crane Iron Works at Catasauqua, Pa. Mr. Hall was graduated from Ohio State University in 1889.

Mr. John E. Stewart, Hydrographic Aid in the Reclamation Service, has been transferred from the Washington office to duty on the Belle Fourche Project, South Dakota.

Mr. C. C. Coffee has been appointed Superintendent of the St. Louis Division of the Southern Railway, with office at Princeton, Ind., to succeed Mr. A. M. Smith, resigned.

Mr. W. S. Hanna, Engineering Aid in the Reclamation Service, now employed in Washington office, has been assigned to duty with C. C. Babb on the St. Mary Project, Montana.

Mr. A. D. Page, Engineer of Bridges and Buildings of the Chicago, Rock Island & Pacific Ry., at Chicago, has been appointed Principal Assistant Engineer, succeeding Mr. E. J. Beard, resigned.

Mr. A. Lincoln Acker, Director of the Department of Public Works, Philadelphia, resigned that office on March 6 and was succeeded by Mr. Thomas L. Hicks, heretofore Assistant Director.

Mr. H. D. Comstock, Assistant Engineer in the Reclamation Service, has been transferred from the Washington office for duty in hydrographic work on the Belle Fourche Project, South Dakota.

Mr. George M. Eba has been transferred from the Accounts Division of the U. S. Reclamation Service at Washington, D. C., to Williston, N. Dak., where he will act as disbursing agent during the construction of the Williston Irrigation Project.

Mr. Claude D. Stephens, Consulting Engineer, Monadnock Bldg., Chicago, announces that he will carry on the business of Stephens & Tyler, consulting and contracting engineers, the partnership between him and Mr. Theodore R. Tyler having been dissolved.

Mr. F. P. Jeffries has been appointed General Purchasing Agent of the Chicago, Rock Island & Pacific System, with offices at Chicago, succeeding Mr. S. F. Forbes, resigned. Mr. Jeffries was formerly General Manager of the Evansville & Terre Haute R. R.

Mr. W. W. Graham has resigned his position as Tie and Timber Agent of the Chicago, Rock Island & Pacific Ry. and that office has been abandoned. All correspondents pertaining to that department should be addressed to the Purchasing Agent, Mr. S. F. Forbes, at Chicago.

Mr. Paul G. Brown, formerly Assistant City Engineer of Chicago, and more recently General Superintendent with the Degnon Contracting Co., New York, has resigned this position to become Manager of the United Engineering & Contracting Co., 32 East 33d St., New York City.

Mr. R. S. Feurtado, Engineer of the Western Gas & Investment Co., Tribune Bldg., Chicago, announces that he is also undertaking a general engineering business in making investigations and reports upon gas, electric and hydraulic properties, and preparing designs for new plants.

Mr. E. J. Beard, M. Am. Soc. C. E., Principal Assistant Engineer of the Chicago, Rock Island & Pacific Ry., at Chicago, has resigned in order to accept a position with J. G. White & Co., of New York, as Chief Engineer of the railways which that company has contracted to build in the Philippine Islands.

Mr. S. C. Brown, Assoc. M. Am. Soc. C. E., has resigned his position of Division Engineer of the New York Division, Erie R R., at Jersey City, to associate himself with A. O. Brown & Co., bankers and brokers, 30 Broad St., New York City, in connection with various enterprises in which this firm is interested.

Mr. Alexander C. Shand, Assistant Chief Engineer of the Pennsylvania R. R., has been appointed Chief Engineer of that road, with headquarters at Philadelphia, Pa., to succeed Mr. W. H. Brown, who retired on Feb. 28, under the provisions of the pension plan. Mr. Edward Brinton Temple, Assistant to the Chief Engineer, has been appointed Assistant Chief Engineer, succeeding Mr. Shand.

The Richardson & Lovejoy Engineering Co. has been formed at Columbus, O., to engage as consulting engineers in the clay industries. The firm is composed of W. D. Richardson, President; Ellis Lovejoy, E. M.; A. V. Bleninger, Vice-President, and C. B. Harrop, E. M., Secretary and Treasurer. All the members of the firm, with the exception of Mr. Richardson, have been graduated from the Ohio State University.

Mr. John F. Murray, Assistant Engineer of Construction of the Pennsylvania R. R., at Lancaster, Pa., has been appointed Assistant to the Chief Engineer, with office at Philadelphia, in place of Mr. Temple. Mr. Henry R. Leonard, Engineer of Bridges, has been appointed Engineer of Bridges and Buildings, with headquarters at Philadelphia. Mr. Murray was graduated from Swarthmore College in 1892, entering the service of the Pennsylvania R. R. in that year.

Mr. C. C. Coffee, Engineer of Maintenance-of-Way of the St. Louis-Louisville lines of the Southern Ry., at St. Louis, Mo., has been appointed Superintendent of the St. Louis division of those lines, with headquarters at Princeton, Ind., to succeed Mr. A. M. Smith, resigned. Mr. J. F. Sheridan has been appointed Assistant Superintendent of that division, and Mr. J. A. Rathburn has been appointed Trainmaster in place of Mr. Sheridan, both with headquarters at Princeton. Effective on March 1.

Gen. Edward W. Serrell, who achieved great prominence in military engineering work in the Civil War, is in the S. R. Smith Infirmary on Staten Island ill with a painful disease of the bladder, and his means have become exhausted so that measures are to be initiated to have Congress take action for his relief, on account of his notable Civil War record. Gen. Serrell's last professional work was in connection with a projected line of railway from Pennsylvania to New England, crossing the Hudson by a great bridge near Peekskill. Gen. Serrell was President and Chief Engineer of the enterprise and a considerable amount of money was raised here and abroad for the work in the early '90's. The financial depression which followed compelled the abandonment of the enterprise and caused heavy losses to those who had invested money in it.

Mr. Arthur Giesler has resigned his position as Chief Engineer of the Platt Iron Works Company, of Dayton, O., and has entered private practice as a Consulting Engineer, with offices at 170 Broadway, New York City. He will devote himself to his specialty of turbine water power plants and pumping stations. Mr. Giesler was born and educated in Germany. He has been connected with water-wheel design and installation for over thirty-five years, of which nearly twenty-five years were in America. As early as 1869 he erected at Dirschau, Prussia, for Professor Fink, of Berlin, Fink's first reaction turbine, fitted with the Fink gate. He came to America in 1882, and entered the employ of the Stillwell-Bierce & Smith-Vaile Co., becoming Assistant Superintendent, and later Superintendent of Works and Chief Engineer, which position he held also after its reorganization as the Platt Iron Works Co. Mr. Giesler has taken a leading part in the advance of turbine construction in this country, and through his European connections and frequent visits to foreign turbine works he has a close acquaintance with all phases of his specialty.

Major Cassius E. Gillette, Corps of Engineers, U. S. A., has resigned his commission as an army officer and has been appointed by Mayor Weaver, of Philadelphia, Chief Engineer of the Water Department, in which position he will have charge of the completion of the new filtration works. Major Gillette was given leave of absence by the War Department authorities last fall in order to serve on a Board of Engineers created by the Philadelphia authorities to investigate the frauds in connection with the water filtration contracts. Secretary of State Root, prior to his appointment to his Cabinet position, was counsel to Mayor Weaver in his work of establishing honest government in Philadelphia, and it is said that

after his removal to Washington he was instrumental in securing Major Gillette's services on the Philadelphia Board of Engineers. Recently an appeal was made to Congress to permit Major Gillette to undertake service for a longer period in Philadelphia, but the permission was refused on the ostensible ground that his services could not be longer spared from the Corps of Engineers. It is conjectured, however, that the political influence which the Philadelphia machine politicians well know how to exert, was the real motive back of the refusal to permit longer absence of Major Gillette from Government work. This has now been checkmated by Major Gillette's resignation. Major Gillette has been for 26 years a member of the Corps of Engineers. He achieved a national reputation by his heroic work in laying bare the conspiracy between Oberlin Carter and the Atlantic Contracting Co. to defraud the Government in the Savannah Harbor contracts, as a result of which Carter was convicted and served a term in the Leavenworth Penitentiary, and the members of the contracting firm, after exhausting every legal technicality and delay and becoming fugitives from justice for years, are now on trial in the U. S. Court in Savannah.

Obituary.

Robert J. Hill, State Superintendent of Public Buildings at Albany, N. Y., died in that city on Feb. 28. Mr. Hill was appointed to the office of Assistant Superintendent on Feb. 28, 1901, and on March 17, 1903, was promoted to the superintendency.

Robert C. Wiggin, a civil engineer, son of the late Edwin R. and Sarah J. Wiggin, of Boston, died on March 5 of pneumonia at the New York Hospital. Mr. Wiggin lived at the Judson Hotel, 53 South Washington Sq. He was 45 years old and leaves a widow.

A. H. Heller, Professor of Civil Engineering at the Ohio State University, died at Columbus, O., on Feb. 20. Mr. Heller, until accepting the university professorship, was engaged in private practice as a consulting engineer in connection with bridge and structural steel projects. He was born at Wapakoneta, O., in 1866, and was graduated from the Ohio State University in 1890 as a civil engineer.

Henry Rustin, M. Am. Inst. El. E., who died at his home in Florence, Neb., on Feb. 27, was prominently connected with the design of the electric illumination and decorative features of the Buffalo and St. Louis exhibitions. He was for some time Chief Electrical and Mechanical Engineer of the St. Louis Exhibition and laid out the general plans for the cascades and the electric features, but had to resign on account of ill-health before the completion of the work.

Samuel P. Langley, Secretary of the Smithsonian Institute, at Washington, D. C., died of paralysis at Aiken, S. C., on Feb. 27. He was 72 years old and a bachelor. He was born in Roxbury, Mass., and was graduated from the Boston Latin School, after which he became an assistant in the observatory at Harvard University. Prof. Langley afterward became a professor in the U. S. Naval Academy, and in 1877 became Secretary to Smithsonian Institute. His whole life had been devoted to scientific work. He was by profession a civil engineer and an architect, but he was better known as an astronomer and an inventor. Prof. Langley's experiments with flying machines, for which the Board of Ordnance and Fortifications, of the War Department, appropriated $70,000, attracted wide attention, and since their failure his health had rapidly broken. The experiments were made at Widewater, Va., in the summer of 1904, and later at the tidal basin near the arsenal, in the District of Columbia. The great Langley flying machine, carrying a man, was propelled from a houseboat. In each case the machine failed to soar, but structural accidents were held responsible both times.

Herbert Gouverneur Ogden, of the Coast and Geodetic Survey, died suddenly on Feb. 25, at Fortress Monroe, Va. He entered the Coast and Geodetic Survey as Aid on April 22, 1863, was promoted to Sub-Assistant Jan. 1, 1869, and to Assistant on Jan. 1, 1872. Since 1898 he had filled the position of Inspector of Hydrography and Topography, having supervision of the hydrographic and topographic work of the survey. Mr. Ogden was born in New York, April 4, 1846, and was the son of Morgan Lewis and Eliza Glendy McLaughlin Ogden. He was educated at private schools and by tutors. He married Mary A. Greene, of Brooklyn, N. Y., May 28, 1872. Mr. Ogden served in 1863 with the army on defenses of this city; in 1864, with the navy in the sounds of North Carolina; in 1865, with the Nicaragua expedition; in 1870, as Topographer with the first naval exploring expedition to the Isthmus of Darien, and in 1893, in charge of the party locating the international boundary between British Columbia and Alaska. He was a member of the Cosmos Club, the United States Board of Geographic Names, the National Geographic Society and Philosophic Society, a fellow of the A. A. A. S., and a member of Washington Academy of Science, a recognized expert in topography and chartography and the author of "Maps," Johnson's Cyclopaedia, and of many articles in scientific journals.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 20-22. Annual meeting at Chicago, Ill. Secy., L. C. Fritch, 1562 Monadnock Block, Chicago, Ill.

AMERICAN RAILWAY ASSOCIATION.
April 25. Semi-annual meeting at Chicago, Ill. Secy., W. F. Allen, 24 Park Place, New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
May 1 to 4. Semi-annual meeting at Chattanooga, Tenn. Secy., F. R. Hutton, 12 West 31st St., New York City.

ENGINEERS' CLUB OF CINCINNATI.—At the next meeting of the club, to be held at rooms of the Literary Club, 25 E. Eighth St., Cincinnati, O., on March 15, Mr. H. C. Innes will read a paper entitled "Some Street Paving Materials and Methods."

NEW ENGLAND WATER-WORKS ASSOCIATION.—The March meeting will be held at Boston, Mass., on March 14, the technical session being held at the Hotel Brunswick at 2 p. m. Mr. M. N. Baker, Associate Editor of Engineering News, will present a paper entitled "Water Supply, Typhoid Fever and Diarrhoeal Diseases at Burlington, Vt., 1879 to 1905 inclusive." A paper on "The Pitometer and its Uses" will be read by Mr. E. M. Blake.

ILLUMINATING ENGINEERING SOCIETY.—The second meeting will be held at the Edison Auditorium, 44 W. 27th St., New York, at 8.15 p. m., March 9. The following papers will be read: "The Inverted Gas Mantle Lamp," by V. H. Rettich; "The Flaming Arc Lamp," by E. L. Elliott; "Artificial Illumination from the Architect's Standpoint," by W. S. Kellogg. The inverted-mantle lamp and the flaming-arc lamp will be shown in operation.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—At the February "Reunion" of the New York members of the society, held Tuesday evening, Feb. 27, at the society house, 12 West 31st St., New York City, Mr. James M. Dodge, of Philadelphia, gave an address on the subject: An Introduction of the Taylor System. The address gave a summarized narrative of how the Link-Belt Engineering Co., of Philadelphia, was led to reorganize the working and management of its shop under the Taylor System. Shortly after Messrs. Taylor and White invented the famous high-speed steel and put it to use in the Bethlehem Steel Works, Mr. Dodge heard of it, and went to see it work. The work was so astonishing that it took time for him to become fully convinced of it, but he then at once proceeded to introduce it at the Link-Belt works. At Bethlehem, mainly steel was worked with the Taylor-White tools, while at Philadelphia cast iron was the principal work; this required distinctly different tools from those used for nickel-steel and armor plate, and the work of introduction was therefore slow. As Mr. Dodge says:

> Then we made hundreds of careful tests, sending back scores of warnout tools with reports to Mr. Taylor, of Bethlehem, who in turn sent us other tools, and, after the expenditure of a great deal of time and considerable money, success was attained, and we had a Taylor-White tool which would do as marvelous work on cast iron as the earlier tools had done on nickel-steel. All this expenditure of time and money and experimenting had resulted in our having one lathe in our shop and a few tools to fit it that would do from three to four times as much work on cast iron as we had ever been able to do before with any other tool.

This was followed by bringing the rest of the shop up to the new standard. It was then found that the new rate of working had badly disorganized the old system of making piecework rates and generally the conduct and management of the works. The more intensive working made the weaknesses of the old system, its points of empiricism and guessing, painfully apparent. Mr. Taylor's system of directing work on the basis of scientific time study of operations was therefore taken up. A description of the principal struggles and difficulties incident to its application to the Link-Belt works formed the essential part of Mr. Dodge's address.

The subject was discussed by C. B. Rearick, George Hill, H. L. Binsse, F. W. Taylor, G. C. Henning, and others, mainly by putting questions which were answered by Mr. Dodge and Mr. Taylor. An important item of information was an opinion on the minimum size of shop to which the complete Taylor system of management could be applied profitably. A shop in Philadelphia employing about 120 men and doing an unusual variety of work has been put under the Taylor system during the past year by Mr. C. G. Barth. Mr. Taylor says that this appears to be about the smallest shop where the system would prove practicable, in work of much variety. In a shop doing exclusively duplicate or stock work a much smaller size could be handled with profit. The shop in question has more than doubled its output during the year, with fewer machines working and with an actual decrease in shop labor; the cost of the planning department, etc., cuts down the increased profits somewhat. In a shop whose available business cannot be increased, the question takes on another aspect. Another bit of information given by Mr. Taylor in reply to a question is that he himself has never attempted to apply his system to pattern-making. A number of shops are doing pattern work under that plan, but he himself has never tried it. Pat[illegible]aking is the most difficult class of shop work in [illegible]gard.

SOCIETY OF CHEMICAL INDUSTRY—New York section discussed the subject, "Smoke P[illegible]tion," at its meeting of Feb. 23. Mr. Thomas [illegible]gton, Commissioner of Health of New York City, [illegible] with a review of governmental regulation of the s[illegible]nuis-ance in America. Regulation, where undertak[illegible]as in nearly all cases been the work of the municip[illegible]. Two exceptions, both recent, are New York a[illegible] Massachusetts: (1) In 1895 the Legislature of New [illegible] State prohibited the use of soft coal within four [illegible]s of Brooklyn City Hall, except for certain uses. [illegible] 1905 the State of Massachusetts prohibited the e[illegible]on of dark smoke for more than six minutes in [illegible]y of Boston, except in certain classes of work. [illegible]cipal acts for the regulation of smoke have been pr[illegible]cated by Philadelphia, Cleveland, St. Louis and a f[illegible] other cities. In Philadelphia a scale of density is [illegible]cribed, and various employs are limited to certain [illegible]ensities for certain periods of time. In St. Louis the height of smoke stacks, as well as density of smoke, is involved in the ordinance; smoke of given density is taken to be more of a nuisance when discharged from a low stack than when discharged from a high one. In New York City there are three provisions under which smoke abatement proceedings may be taken, the public nuisance section of the Penal Code, the law for the control of dangers to life and health, and a specific smoke section of the Sanitary Code. The latter is the present basis of prosecution. The attempts to abate the smoke nuisance under this section have had very discouraging results. One judge went to the extreme of holding the section void and against public policy, on the ground that literal enforcement would practically prevent the combustion of fuel in the city. Improvement, in the opinion of Mr. Darlington, is to be looked for in the direction of defining the means which produce or may produce smoke, and requiring specific construction. During the past year the Board of Health has proceeded against smoke offenders by summary Board Orders; nearly 200 cases were abated by this means. However, as this employs the extreme power of control of the Board (a power without parallel in the municipality and intended for extraordinary necessity such as the control of infectious diseases) the Board does not like to use it for matters such as smoke abatement. On the whole, the remarks of Mr. Darlington did not give a very encouraging view of the state of Smoke Abatement, especially if it be remembered that the cheapness of anthracite coal at New York City makes the nuisance less serious and more easily handled than in most other parts of the country.

Mr. A. De Trampe gave a brief argument for the importance of smoke prevention. He estimated that the coal burned in New York City discharged some 640 tons of coal dust in the smoke per day.

Mr. L. H. White, in a paper entitled "Down Draft Without Grates," described a furnace construction in which the coal is fed into a short chute or passage, 5 to 7 ins. long, 7 to 10 ins. high and of any desired breadth, inclined slightly downward toward the back, beyond which is a combustion chamber. The coal fed at the outside is coked by the radiant heat of the incandescent fuel behind, and the gases are drawn back through the mass and burn in the combustion chamber beyond. A flat or sloping grate may be arranged behind the feeding chute or "combustion passage," upon which the incandescent fuel burns. By the latter means the furnace may be brought up to a capacity of 12 to 15 HP. per lin. ft. of breadth. Several furnaces of this form are in operation. Smoke is absent, and the labor and care of attendance are said to be not much different from that with ordinary furnaces.

Mr. W. Bowman described an experiment with the filtration of smoke through asbestos fabric, in a dust-catching machine comprising an iron cylinder studded with tubular spines or closed stockings of the fabric. The smoke goes into the cylinder through the end plate, and passes out through the stockings; the cylinder is slowly rotated and the row of stockings at the top is automatically cleaned by dumping into a longitudinal dust conveyor. The machine filtered the smoke perfectly, but after five or six hours the fabric was clogged, which apparently was due to a deposit of fine tarry matter in the fabric.

Mr. E. H. Foster described the Kent "Wing-wall" furnace for boilers. In this furnace two walls projecting inward from the sides of the setting, some distance behind the bridge wall, form a vertical gap through which the fire gases must pass. The gases having previously been in a horizontal sheet when passing over the bridge wall become thoroughly mixed by passing through the vertical gap, and burn in a combustion chamber beyond. The edges of the wing-wall gap act to some extent as heat reservoirs, ensuring the ignition of the mixed gases when an inrush of air, or distillation of fresh fuel, makes them too cool to ignite merely by mixture.

Papers by Mr. W. R. Roney on "Smoke and Smoke Prevention as Affected by Furnace Construction," and Mr. O. Nagel on "Smoke Prevention by Means of Down Draft Fire and Gas Firing" were read by title only.